CHAPMAN'S

MINERAL INDICATOR.

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THE
MINERAL INDICATOR:
A PRACTICAL GUIDE
TO THE DETERMINATION OF
GENERALLY-OCCURRING MINERALS.

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ADVERTISEMENT.

In 1880, the author of this little Manual published an extended series of Tables for the determination of all known minerals. In these Tables, an attempt was made to place together, as a rule, minerals of related composition only. During the four years that have elapsed since the publication of the Tables in question, the advantages of this plan have been fully proved in the author's laboratory by students of sufficiently advanced standing to work out readily the distinctive characters on which the Tables are based. But experience has also shown that something of a less elaborate description would be better adapted to the requirements of students just entering on the study of minerals. Hence, the publication of these simplified Tables, by which—as regards substances of ordinary occurrence—the name and nature of any mineral may be very easily and rapidly ascertained. All that is required for this purpose is a very slight acquaintance with mineral terminology, and a few hours' preliminary practice in the use of the blowpipe.

As regards general interest and frequency of occurrence, minerals may be referred to four series. To the first belong all minerals of common occurrence ; to the second, minerals of more or less rare occurrence but of economic value or otherwise of importance ; to the third, exceptionally occurring and comparatively unimportant minerals ; and to the fourth, obscurely known and ill-defined or doubtful species. These Tables include all representatives of the first and second series, and consequently all minerals that are likely to come under the observation of the general student or practical explorer.

In determinative tables of this kind, a sub-division into two leading sections, based on the lustre or aspect of the substance, is commonly adopted ; but, beyond this, the present Tables are entirely distinct in their construction from those of the larger work referred to above, and also from all other determinative tables hitherto published.—E. J. C.

School of Practical Science, Toronto,
February 17, 1884.

PRELIMINARY NOTICE

INCLUDING

GENERAL INSTRUCTIONS TO BE OBSERVED IN USING THE TABLES.

1. The aspect (or lustre) and the colour of a mineral must be determined, as a rule, on a perfectly unaltered or newly-fractured surface. Minerals of metallic lustre, more especially, frequently present a deceptive surface character from the assumption of a dark or other tarnish.

2. When a mineral presents a sub-metallic aspect it will probably be found in both divisions of the Tables; but in doubtful cases it should be sought for more especially in the second division. A ready test, with regard to lustre in these doubtful cases, is as follows:—Let the student ask himself the question, "would this substance, *from its appearance*, be taken by an observer, ignorant of mineralogy, for a piece of gold, or brass, or copper, or bronze, silver, lead, tin, steel, or iron?" If the answer be in the negative, the name of the substance should be sought for under Division II.

3. Minerals of metallic lustre, proper, are always opaque, even in thin splinters, and their streak or powder is always distinctly coloured. Minerals of pseudo-metallic or metallic-pearly lustre (as the various micas), on the other hand, are commonly translucent or transparent in thin pieces, and their streak is either white or lightly tinted. Substances of this latter description, therefore, must be sought for under Division II. of the Tables.

4. When a mineral scratches glass (*i. e.*, ordinary window-glass) very feebly or doubtfully, it should be sought for principally under § 2 of the Division (metallic or non-metallic) to which it belongs. In trying

the hardness of a mineral, the operator should place a piece of glass flat upon a table, and then draw the mineral sharply across it—taking care to see previously that particles of quartz or pyrites are not present in the substance.

5. Minerals which fuse with extreme difficulty, or only become vitrified and rounded on the thinnest edges, are placed in these Tables (in order to avoid risk of error) under both the fusible and infusible groups of the section to which they belong. In trying the fusibility of a mineral, beginners should be careful to operate only on thin and sharply-pointed splinters; not on comparatively broad and thick-edged fragments. (See the author's BLOWPIPE PRACTICE, pages 8, 9.)

6. As an additional guide to determination, the essential components of the various minerals included in the Tables are briefly indicated; but where percentages are given, these, for simplicity, are stated as a rule in whole numbers only.

7. As this little handbook is intended to be used by students almost at the beginning of their mineralogical studies, all crystallographic references (beyond a few bare indications) have been purposely excluded from the Tables. A synopsis of the crystallization characters of the more important mineral species will be found in the Notes attached to the Determinative Tables of the author's BLOWPIPE PRACTICE, page 102 to page 298. In these Notes, also, the spectroscopic characters of minerals are fully given—a feature not found in other works.

8. The following works on Determinative Mineralogy should also be consulted by more advanced students :—(1) Tafeln zur Bestimmung der Mineralien, by the late Professor von Kobell, of Munich, (12th ed. by K. Oebbeke, 1884). (2) The American edition of von Kobell's "Tafeln," re-arranged and amplified by Professor George J. Brush. And (3) the Anleitung zum Bestimmen der Mineralien, by Dr. Fuchs, of Heidelberg.

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THE

MINERAL INDICATOR.

TABLE I.

[Lustre metallic. Hardness sufficient to scratch glass strongly. Colour, brass-yellow.]

Iron Pyrites (Fe 47, S 53 = FeS^2); *Marcasite* (Fe 47, S 53).

These minerals are chemically identical, but differ in crystallization, and to some extent in other physical characters. *Iron Pyrites* belongs to the Regular or Isopolar System;* and when crystallized, is commonly in cubes, pentagonal dodecahedrons, or combinations of these forms. Its sp. gr. = 4·9 to 5·1. *Marcasite* is Rhombic in crystallization, and occurs commonly in groups of prismatic crystals often arranged in crested rows (= "Cockscomb Pyrites," "Spear Pyrites," &c.). Its sp. gr. = 4·7 to 4·9, and its colour is usually somewhat paler than that of Iron Pyrites, proper. It has, moreover, a great tendency to fall into decomposition. Massive and radio-fibrous varieties of both species are also common. BB, both emit a sulphurous odour, and melt readily into a dark magnetic globule. Ignited in a narrow test-tube or bulb-tube, both yield a sublimate of sulphur.

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* The term "Isopolar" has reference to the fact, that, in this system of crystallization, all the planes, edges, and angles, at the poles or extremities of the axes are absolutely alike.

TABLE II.

[Lustre metallic. Hardness sufficient to scratch glass distinctly. Colour, tin-white or silver-white.]

Cobaltine (CoFe 35, As 45, S 20); *Smaltine* (CoNi 28, As 72).
Arsenical Pyrites or *Mispickel* (Fe 34, As 46, S 20).

These minerals fuse on charcoal with emission of copious arsenical fumes, easily recognized by their garlic-like odour. The resulting dark globule is magnetic. Ignited gently in a piece of open tubing, they yield a crystalline sublimate of As^2O^3.

Cobaltine and *Smaltine,* after roasting, colour borax BB deep-blue; but only the smallest particle must be used, otherwise the glass will be so intensely coloured as to appear black and opaque. Both occur commonly in small crystals of the Regular or Isopolar System: *Cobaltine* chiefly in combinations of cube and pentagonal dodecahedron; *Smaltine* chiefly in octahedrons. Both, also, occur massive, dendritic, &c. *Cobaltine* is bright silver-white in colour; *Smaltine,* greyish tin-white, and the latter (if quite pure) yields no sulphur-reaction BB with carb. soda. In both, the sp. gr. exceeds 6·2. *Mispickel* or *Arsenical Pyrites* is silver white in colour, but rapidly tarnishes dull-grey. It occurs massive, and in rhombic prisms, mostly terminated by two flat summit-planes, transversely striated. Sp. gr. 6 to 6·3. Some varieties are cobaltiferous, and most examples contain small but workable amounts of gold.

TABLE III.

[Lustre metallic or sub-metallic. Hardness sufficient to scratch glass distinctly. Colour, iron-black, steel-grey, or metallic-brown.]

In most of their examples, the minerals of this Table (those of steel-grey colour excepted) present merely a sub-metallic aspect. None emit fumes or odour when ignited BB on charcoal.

FIRST GROUP: *Anhydrous species. No water produced by their ignition in a bulb-tube or test-tube.*

Magnetite (Fe 72·4, O 27·6). *Franklinite* ([ZnO, MnO, FeO] Fe^2O^3). *Chromotite* (FeO 32, Cr^2O^3 68).

Hematite (Fe 70, O 30). *Ilmenite* (Fe^2O^3, Ti^2O^3). *Rutile* (TiO^2). *Anatase* (TiO^2). *Wolfram* (FeO, MnO, WO^3).

Magnetite (= *Magnetic Iron Ore*), *Franklinite*, and *Chromolite* (= Chromic Iron Ore), are the principal representatives of a group of oxides of the common formula [RO, R^2O^3] and of Regular or Isopolar crystallization—their common forms being the octahedron and rhombic dodecahedron. Massive and granular varieties are also common. In some of the rarer representatives of the group (*Ferro-magnesite*, &c.) part of the FeO is replaced by MgO. *Magnetite* is always strongly magnetic, often shewing polarity; and *Franklinite* is very commonly magnetic also. In *Magnetite* the powder is black; in *Franklinite* (when free from magnetite) it is usually dark-brown; and the latter species gives a strong Mn-reaction by fusion with carb. soda. It is generally in small rounded grains or crystals, with red zinc ore or pale-red garnets, in crystalline limestone. In both, the average sp. gr. = 5·0. *Chromolite* is much like granular varieties of magnetite, but is feebly or not at all magnetic, and its sp. gr. averages 4·5 only. With borax, BB, it forms a fine green glass.

Hematite (= *Specular Iron Ore, Red Iron Ore*) and *Ilmenite* (= Titaniferous Iron Ore) are Rhombohedral in crystallization, the crystals being usually flat or thin-tabular; but lamellar, granular, scaly, and other varieties are also common. *Hematite* (as regards examples of metallic lustre) is steel-grey in colour, often with iridescent tarnish, and the streak is normally dull-red. BB, thin splinters fuse in the RF, at the extreme point, and become magnetic. In *Ilmenite* the streak is black or brownish. When in fine powder, the latter species is slowly dissolved by boiling in hydrochloric acid, and the slightly diluted solution when boiled with a piece of metallic tin becomes first colourless and then assumes an amethystine tint. Titaniferous examples of magnetite and hematite, however, shew the same reaction.

Rutile and *Anatase* are metallic adamantine in lustre, and only certain varieties can be referred to this Table. They are chiefly distinguished from the other minerals of the Table by their lower sp. gr. (3·9 to 4·3), and by the amethystine or blood-red glass which they form BB with phosphor-salt in a reducing flame. *Rutile* (when the lustre approaches sub-metallic) is dark-red, brown, or black, with light-brown streak, and is either in square-prismatic crystals (often geniculated), or in rolled pebbles. Sp. gr. 4·2 to 4·3; nearly as hard as quartz. *Anatase* is brown or indigo-blue in colour, and is commonly in small, acute octahedrons; sp. gr. 3·9 to 4.

Wolfram (a tungstate of iron and manganese) is black or bronze-brown, and sub-metallic, only, in lustre. It is readily distinguished from the other minerals of this Table by its high sp. gr. (over 7·0), and its comparatively easy fusion. It melts BB into a magnetic globule with crystalline surface, and gives a strong Mn-reaction with carb. soda. Mixed, in fine powder, with carb. soda and nitre, and fused in a platinum spoon, it forms an alkaline tungstate, soluble in hot water. The solution (which is of a green colour from presence of manganate of soda) when filtered or decanted from the insoluble residuum, acidified with a few drops of hydrochloric acid, and boiled with a piece of tin or zinc, becomes rapidly colourless and then assumes a deep indigo-blue colour.

SECOND GROUP: *Hydrous species: yielding water by ignition in a bulb-tube or test-tube.*

Limonite: some varieties (Fe^2O^3 85·6, H^2O 14·4).

Psilomelane (Mn^2O^3, MnO, BaO, K^2O, H^2O).

Limonite (= Brown Iron Ore) as a rule, presents a non-metallic aspect, but some varieties are sub-metallic. On ignition, it becomes first red and then black and magnetic—the latter in the RF., or by ignition in a bulb-tube. Black or brown in colour, with brownish-yellow streak. Massive, fibro-botryoidal, &c. Sp. gr. 3·5 to 4·0. A thin splinter fuses BB at the extreme point.

Psilomelane occurs in iron-black or dark steel-grey amorphous masses with dark-brown or brownish-black streak. Non-magnetic after ignition. With carb. soda BB, it gives a strong Mn-reaction.

TABLE IV.

[Lustre metallic. Hardness not sufficient to scratch window-glass. Malleable or Ductile.]

The representatives of this Table comprise a small number of native metals and one malleable sulphide. These bend before breaking, and when broken shew a "hackly" fracture. On the anvil, they flatten under the hammer.

FIRST GROUP: *Readily fusible, BB, on charcoal.*

Native Gold. *Native Silver.* *Silver Glance* (Ag 87, S 13). *Native Copper.*

These minerals are readily distinguished from other minerals of ordinary occurrence by their malleability; and, individually, by their respective colours:—gold-yellow—silver-white with dark surface-tarnish—iron-black—copper-red. The metallic globule obtained by fusion on charcoal, in the case of *N. Gold*, *N. Silver*, and *Silver Glance* (= Argentite) retains its bright surface on exposure to an oxidating flame; that obtained from *N. Copper* becomes coated with a film of black oxide, and the point of the flame is coloured green. N. Gold is not attacked (if pure) by nitric acid, but is dissolved by nitro-hydrochloric acid: the solution, rendered colourless by dilution, assumes a purple colour by heating with tin-foil. *N. Silver* and *Silver Glance* are readily dissolved by nitric acid (sulphur separating as a yellowish-grey, flocculent powder in the case of *Silver Glance*), and the solution yields a white curdy precipitate with a few drops of hydrochloric acid. The precipitate blackens on exposure. *N. Copper* is also readily dissolved by nitric acid. The green solution, diluted and treated with ammonia in excess, becomes intensely blue. These minerals belong equally to the Regular System of crystallization, but *N. Gold* is commonly found in grains or small nuggets in alluvial gravels and the sands of river-beds, or disseminated through quartz veinstones; *N. Silver* and *Silver Glance* are commonly in wire-like or dendritic forms, or in small scaly or leafy masses, or occasionally in distinct crystals (cubo-octahedrons, &c.); and *N. Copper* presents similar forms of occurrence, besides occurring, in places, in sheets and masses of large size. The sp. gr. of *N. Gold*, in consequence of the presence of a small but variable amount of silver, ranges from 15·5 to 19·4 (average: 17 to 18). The sp. gr. of *N. Silver* equals 10·5; that of *Silver Glance*, 7·1 to 7·4; and that of *Native Copper*, 8·5 to 8·9.

⁂ The silver-telluride, *Hessite* (blackish steel-grey; sp. gr. 8·1 to 8·5); the silver-gold-telluride, *Petzite* (sp. gr. 8·7 to 9·4); and the silver-selenide, *Naumannite* (iron-black, sp. gr. 8), also belong to this group. BB, all yield a button of silver or gold-silver, and form (as in the case of *Argentite* and other sulphides) by fusion with carb. soda a dark, alkaline slag or "hepar," which imparts a dark stain, when moistened, to the surface of a silver coin, or piece of lead test-paper. *Naumannite*, also, during fusion gives off selenium-fumes, recognized by their disagreeable odour which resembles that of decaying vegetable matters.

SECOND GROUP: *Infusible BB on charcoal.*

Native Platinum. Meteoric Iron.

Native Platinum is distinguished by its high sp. gr. (averaging 17 to 20), and its insolubility in the blowpipe fluxes and in nitric acid. Its colour is between silver-white and pale steel-grey—the darker varieties being often attractable by the magnet in consequence of the presence of iron.

It occurs in the form of grains and scales, or occasionally in small nuggets in river-sands and other alluvions, sometimes accompanied by small grains of *Iridium*, *Palladium*, and other so-called "platinum metals." *Meteoric Iron* is steel-grey in colour, commonly with brown surface-tarnish, and is strongly magnetic. It is found mostly in large irregular masses, or otherwise in small grains scattered through stony aerolites Nearly all examples contain a small percentage of nickel. Sp. gr. 7 to 7·8.

TABLE V.

[Lustre metallic. Hardness not sufficient to scratch glass. Not malleable. Colour silver-white or tin-white.]

FIRST GROUP: *Volatilizable wholly (or leaving very slight residuum) BB on charcoal.*

Native Mercury.
Native Bismuth.
Native Arsenic.
Native Antimony. *Native Tellurium.*

Native Mercury is easily distinguished by its fluid or semi-fluid condition. It occurs in small globules in certain Palæozoic slates and sandstones. Readily soluble in nitric acid. The other native metals of this Table present a lamellar, cleavable structure. *N. Bismuth* is reddish silver-white in colour. BB, it forms a deep-yellow coating of oxide on the charcoal, or a vivid scarlet coating if fused with a mixture of sulphur and potassium iodide. Sp. gr. 9·7. *N. Arsenic* occurs in tin-white, botryoidal and concentric-lamellar masses, which rapidly tarnish dark-grey or black. BB, it volatilizes without fusing, and is easily recognized by the strong garlic-like odour of the evolved fumes. The flame-point is tinged light-blue. Sp. gr. = 6. *N. Antimony* and *N. Tellurium* (if pure) fuse readily BB, and give off copious fumes which form a dense white ring-deposit (slightly yellowish whilst hot) upon the charcoal, tinging the flame-point at the same time light-green. The fumes are practically without odour. Both metals, when untarnished, are tin-white in colour. *N. Antimony* is converted in nitric acid into a yellowish-white powder. *N. Tellurium* dissolves in nitric acid. The latter metal when warmed with sufficient quantity of strong sulphuric acid forms a purplish-red solution, which becomes colourless on addition of water, tellurium falling as a dark-grey precipitate.

⁂ The rare lead-telluride, *Altaite*, may also be referred to this group, as on charcoal, in a reducing flame, it volatilizes almost entirely. Tin-white; sp. gr. about 8·2.

SECOND GROUP: *Partly volatilizable BB on charcoal, a large silver-globule remaining.*

Native Amalgam (Ag, Hg).

Dyscrasite (Ag, Sb).

N. Amalgam yields no ring-deposit, BB, on charcoal. *Dyscrasite* yields a dense white deposit. Both are silver-white in colour with yellowish or greyish tarnish. Ignited in a narrow test-tube, *N. Amalgam* yields a grey or metallic sublimate which runs into fluid globules when rubbed by a thin wire or glass rod. Some varieties contain gold. Sp. gr. 11 to 14 or 15. Sp. gr. of *Dyscrasite*, 9·4 to 10.

TABLE VI.

[Lustre metallic. Hardness insufficient to scratch glass distinctly. Not malleable. Colour, brass-yellow, bronze-yellow, or pale copper-red.]

Arsenical Nickel (NiFe 43½, As 56½),

Magnetic Pyrites (Fe 60½, S 39½).

Copper Pyrites (Cu 34½, Fe 30½, S 35).

Purple Copper Pyrites (Cu, Fe, S– the Cu about 56 %).

Arsenical Nickel (= *Nickeline, Copper-Nickel,* &c.) gives off, BB, copious arsenical fumes of strong garlic-like odour, by which character alone it may be distinguished from the other minerals of the Table. Its pale copper-red or yellowish-red colour and its high sp. gr. (= 7·5 to 7·7) are also characteristic. The fused globule has a crystalline surface, and in general is not magnetic; but in those varieties in which iron replaces a considerable portion of the nickel, the globule becomes magnetic after prolonged ignition.

Magnetic Pyrites (= *Pyrrhotine*) is readily distinguished by its magnetism. Occurs chiefly in cleavable masses of a bronze or brownish-yellow colour. Sp. gr. 4·4 to 4·7. Decomposed by hydrochloric acid, with separation of sulphur and emission of sulphuretted hydrogen odour. Whilst *Common Pyrites* (FeS^2) yields a grey or yellow sublimate of sulphur by ignition in a narrow test-tube or bulb-tube, *Magnetic Pyrites* (practically, FeS) yields none.

Copper Pyrites (= Chalkopyrite, yellow copper ore) and *Purple Copper Pyrites* (= *Bornite,* "*Horseflesh Ore,*" &c.) are at once distinguished by their copper reactions from the other minerals of the Table; but to shew these reactions properly, the test-matter must be crushed to powder and *thoroughly roasted* before being fused with borax on platinum wire, or with soda on charcoal for production of metal. The borax glass in the OF is deep-green hot, and light-blue (or greenish-blue from presence of iron) when cold; and in the RF, when cold, brick-red and opaque—the red colour being due to the reduction of CuO to Cu^2O. *Copper Pyrites* presents a more or less rich yellow-colour with blackish-green streak, and is commonly massive, though sometimes in tetrahedral and other crystals of the Tetragonal System. Many examples shew an iridescent tarnish ("Peacock Copper Ore," &c.). *Purple Copper Pyrites* when newly broken presents a peculiar reddish colour, but this is rapidly masked by a rich blue or greenish-blue tarnish. Commonly massive; streak, black; sp. gr. 4·6 to 5·2. The sp. gr. of *Copper Pyrites* = 4·1 to 4·3. Both yield by fusion a black magnetic globule, and impart a green colour to the point and border of the flame. *Cubanite* is very similar in composition and general characters, but is cubical in crystallization and cleavage.

⁂ To this group also belong the nickel-antimonide, *Breithauptite* (light copper-red with blueish tinge, H 5, sp. gr. 7·5, fusible with antimonial fumes into a hard, magnetic globule); and the nickel-sulphide *Millerite* (brass or bronze-yellow, in acicular examples only, fusible into a magnetic globule without deposition of sublimate on the charcoal support).

TABLE VII.

[Lustre metallic or sub-metallic. Hardness insufficient to scratch glass. Colour, lead or steel-grey, brown, or black. Not malleable. Readily fusible or volatilizable.]

FIRST GROUP: *Giving BB, strong manganese-reaction with borax or carb. soda. Brown or Black, with sub-metallic lustre.*

Wolfram (MnO, FeO, WO^3).

Some examples of this mineral scratch glass very feebly: hence the species is referred to again in the present Table (see fuller description in Table III.). Brown, black, sub-metallic; sp. gr. 7·1 to 7·5. Easily fusible into a dark (usually magnetic) globule with crystalline surface.

SECOND GROUP: *Giving BB (after thorough roasting) a strong copper-reaction with borax. Lustre distinctly metallic.*

Copper Glance (Cu 80, S 20).

Grey Copper Ore (Cu, Sb, S). *Tennantite* (Cu, As, S).

Bournonite (Cu 13, Pb 42, Sb 25, S 20).

The presence of copper in these ores may also be readily ascertained in the wet way. A small portion of the test-matter, in powder, is gently boiled for a minute or two in strong nitric acid. The solution, diluted with about an equal volume of water, is then filtered or decanted from insoluble matters, and two or three volumes of strong ammonia are added; a rich blue colour will result.

Copper Glance (= *Chalkosine, Vitreous Copper Ore*, &c.) yields no sublimate BB on charcoal. *Grey Copper Ore* (= *Tetrahedrite Fahl Ore, Panabase*, &c.) and *Tennantite* (= *Arsenical Fahl Ore*) form white ring-deposits, accompanied in *Tennantite* by a strong garlic-like odour. *Bournonite* forms a white and yellow ring-deposit. *Grey Copper Ore* and *Tennantite* occur chiefly in small tetrahedrons and related crystals of the Regular System, but the first occurs also uncrystallized. Both are iron-black or steel-grey in colour. Sp. gr. 4·4 to 5·4. *Bournonite* and *Copper Glance* are also dark in colour, but crystallize in forms of the Rhombic System. The first is readily distinguished by the dense antimonial and lead fumes which it evolves on ignition, and by its nitric acid solution yielding a white precipitate with sulphuric acid. Sp. gr. 5·8. *Copper Glance* BB, boils and spirts, and finally yields a copper-globule. Commonly massive, and often coated in places with an earthy green incrustation or with green and blue tarnish. Sp. gr. 5·5 to 5·8. The crystals have in general a pseudo-hexagonal aspect;

⁂ To this group belong also the following species of rare occurrence: *Stromeyerine* (Ag, Cu, S; sp. gr. 6·2 to 6·3); *Eukairite* (Ag, Cu, Se); and *Aikinite* (Cu, Pb, Bi, S). *Stromeyerine* and *Eukairite* give BB a dark, malleable globule, which on cupellation leaves a large button of silver. *Eukairite* gives off also, during fusion, the characteristic selenium-odour, resembling that of decomposing vegetable matter. *Aikinite*, forms BB a yellow coating on the charcoal support, and when fused with potassium-iodide it gives a vivid scarlet coating. Essentially in acicular crystals; sp. gr. 6·7.

⁂ The comparatively rare *Tenorite*, CuO, in small hexagonal plates or scales from Vesuvius, also belongs to this group. It presents a steel-grey or iron-black colour, and is easily reduced, BB on charcoal, to metallic copper. From *Copper Glance* it is readily distinguished by not giving any sulphur-reaction by fusion with carb· soda.

See also (in Table XVII.) *Cuprite* or *Red Copper* Ore, in which the lustre sometimes approaches to sub-metallic. Colour dark-red, passing in some examples into blueish lead-grey. Streak, red.

THIRD GROUP: *No copper-reaction manifested.*

Galena or *Lead Glance* (Pb 86½, S 13½).

Bismuth Glance (Bi 81, S 19).

Antimony Glance (Sb 72, S 28).

Jamesonite (Pb 50, Sb 30, S 20).

Zinkenite (Pb 36, Sb 42, S 22).

Pyrargyrite or *Dark Red Silver Ore* (Ag 60, Sb 22, S 18).

Galena, Bismuth Glance, Jamesonite, and *Zinkenite,* form BB on charcoal a yellow or white and yellow sublimate or ring-deposit. *Antimony Glance* and *Pyrargyrite,* if pure, form a white sublimate, only.

Galena is at once recognized by its high specific gravity, which exceeds 7, and by its rectangular cleavage. It occurs both massive and crystallized, commonly in cubes and "cubo-octahedrons," and it breaks readily into cubical fragments. BB generally decrepitates, volatilizes in great part, and then melts into a malleable lead-globule. H 2·5; sp. gr. 7·3 to 7·6. Lead-grey in colour.

Bismuth Glance occurs mostly in fibrous or acicular examples of a lead-grey colour. H 2 to 2·5; sp. gr. 6·4 to 6·7. BB yields a more or less brittle globule. and a dark-yellow ring-deposit. When fused in powder with potassium iodide, a ring-deposit of a vivid scarlet colour is obtained.

Antimony Glance fuses in the flame of a candle, and volatilizes BB in dense white fumes, tinging the flame-point distinctly green. It occurs chiefly in fibrous and lamellar masses of a light lead-grey colour; more rarely in elongated rhombic prisms with pyramidal summits. H 2; sp. gr. 4·5 to 4·7. The powder rapidly becomes orange-red in a hot solution of caustic potash.

Jamesonite and *Zinkenite* form BB on charcoal a white and yellow ring-deposit from the presence of antimony and lead. Both are between lead-grey and steel-grey in colour, and occur in fibrous, lamellar and acicular examples, and in small, rhombic crystals. In a hot solution of caustic potash, their powder is readily decomposed, Sb^2S^3 is dissolved out, and black PbS remains A few drops of hydrochloric acid precipitate the Sb^2S^3 in orange-red flocks. *Jamesonite* presents a marked cleavage in one direction, and is too soft to scratch crystalline calcite; its sp. gr. equals 5·5 to 5·65. Zinkenite is hard enough to scratch calcite, and its sp. gr. does not exceed 5·4.

Pyrargyrite or *Dark Red Silver Ore* is readily distinguished by its red streak and metallic-adamantine lustre. Also by yielding on charcoal BB, a large silver-globule. The ordinary colour is iron-black inclining to reddish lead-grey, but thin pieces by transmitted light are ruby-red. H 2 to 2·5; sp. gr. 5·75 to 5·85. Fusible *per se*, without the aid of the blowpipe, if held in the form of a small fragment against the outer edge of a candle or other flame. In caustic potash, partly dissolved—the solution yielding an orange-red precipitate of Sb^2S^3 on addition of a few drops of hydrochloric acid.

⁂ Many other examples of silver and lead sulphantimonites belong to this Table, but are of comparatively exceptional occurrence. As a rule, unless in distinctly crystallized examples, they can only be distinguished by actual analysis. Some of the best known of the argentiferous species comprise: *Miargyrite*, *Polybasite*, *Stephanite*, *Freislebenite*, and *Brongniardite ;* whilst the more common lead species include *Plagionite*, *Boulangerite*, *Meneghinite*, &c. See ordinary text-books. Also the author's BLOWPIPE PRACTICE, pages 110 to 112.

⁂ The rare lead-selenide, *Clansthallite*, and mercury-selenide, *Tiemannite*, also belong to this group ; to which likewise the equally rare tellurides, *Nagyagite*, *Sylvanite* and *Tetradymite*, may be referred. Selenides are recognized by the strong odour (resembling that of decaying vegetable matter) which they evolve in the blowpipe flame. Tellurides, in fine powder, are decomposed by sulphuric acid, the tellurium dissolving, and forming a purplish-red solution. On addition of water, the tellurium is thrown down as a dark-grey precipitate, and the solution becomes colourless.

⁂ See also *Cinnabar* (Table XIV), which presents in some exceptional examples a lead-grey colour on the surface. Streak red. BB inflammable and entirely volatilizable.

TABLE VIII.

[Lustre metallic or sub-metallic. Hardness not sufficient to scratch glass. Not malleable. Colour, metallic-grey, black, or brown. Infusible, or fusible on thinnest edges only.]

The minerals of this Table are, as a rule, quite infusible, but in some few cases, especially in the inner blowpipe-flame, signs of fusion are exhibited at the extreme point of the test-fragment. None can be brought into a globule on charcoal. Two *(Zinc Blende* and *Molybdenite)* yield a slight sublimate after strong ignition, but none give off distinct fumes.

First Group : *Occurring in examples of scaly or foliated structure, or in greasy-feeling scaly-compact masses, or in small disseminated scales.*

Graphite (Carbon more or less pure).

Molybdenite (Mo 59, S 41).

Scaly Red Iron Ore (Fe 70, O 30).

Graphite and *Molybdenite* have a black shining streak ; *Scaly Iron Ore*, a red streak. *Graphite* (= Plumbago) is not attacked BB by borax, the small scales float on the surface of the bead. *Molybdenite* is attacked very slowly by that reagent, the scaly particles, like those of graphite, coat the surface of the bead. *Scaly Iron Ore* is readily dissolved BB by borax, communicating to the glass the characteristic iron tints. Thin scales fuse on the edges, and become black and magnetic after sufficiently prolonged ignition in the inner flame. *Graphite* and *Molybdenite* deflagrate in fused nitre, the latter vividly. *Molybdenite*, however, is best distinguished from *Graphite* by the livid or pale green colour which it imparts to the blowpipe-flame, or to the outer edge of a Bunsen-flame. It forms, but not readily, an alkaline sulphide BB with carb. soda, which stains silver foil. *Graphite* is iron-black or steel-grey, *Molybdenite* somewhat lighter, or lead grey, in colour ; and both leave a black shining mark on paper.

Second Group : *Occurring in crystals or masses of lamellar or fibrous structure, never in foliated masses.*

Pyrolusite (Mn 63, O 37, = MnO^2).

Manganite (Mn^2O^3 91, H^2O 9).

Alabandine (Mn 63, S 37).
Hauerite (Mn 46, S 54, = MnS^2).
Zinc Blende (some examples: Zn 67, S 33).

Pyrolusite is iron-black or dark steel-grey with black streak, and is usually in soft fibrous masses which soil the hands and leave a dark trace on paper. *Manganite* is steel-grey, and commonly in groups of acicular or small prismatic crystals, with dark-brown streak. *Alabandine* is chiefly brownish-black or dark-steel grey, with greenish streak and sub-metallic lustre, and it occurs mostly in granular masses with well-marked cubical cleavage. *Hauerite* is dark-brown with reddish-brown streak, and feebly sub-metallic lustre (see Table XIX.) *Zinc Blende* (= Sphalerite) is sub-metallic in lustre only in certain dark-coloured varieties, and the streak is pale-brown (see Table XIX.)

Pyrolusite and *Manganite*, give strong Mn-reaction BB with carb. soda; and if warmed in hydrochloric acid they produce a strong odour of chlorine. *Pyrolusite* is anhydrous; *Manganite* gives off water by ignition in a narrow test tube or bulb tube. *Alabandine* and *Hauerite* also give a strong reaction of manganese BB with carb soda, but in hot hydrochloric acid they emit an odour of sulphuretted hydrogen. Ignited in a narrow test-tube, *Alabandine* yields no sublimate; *Hauerite* gives a sublimate of sulphur, and becomes green. *Zinc Blende*—a mineral of very common occurrence, whilst the two manganese sulphides are comparatively rare—also emits an odour of sulphuretted hydrogen in hydrochloric acid. Fused in powder, with a mixture of carb soda and borax on charcoal, it forms an alkaline sulphide and coats the charcoal with a ring deposit of zinc oxide, pale-yellow whilst hot and white when cold. Moistened with a drop of cobalt nitrate, and again ignited, the coating becomes on cooling light-green. The alkaline sulphide produced by fusion with carb soda, when moistened and placed on a silver coin, causes a dark stain. The sp. gr. of *Zinc Blende* = 3·9 to 4·2.

TABLE IX.

[Lustre non-metallic. Hardness sufficient to scratch glass distinctly. Streak-powder, coloured.]

The minerals of this Table exhibit for the greater part a somewhat doubtful position as regards their lustre. In many examples, the lustre is distinctly metallic or sub-metallic, whilst in others it would be generally regarded as non-metallic. Hence, to avoid risk of error in their determination, they are referred in this hand-book to both sub-divisions.

FIRST GROUP : *Readily fusible.*

Wolfram (FeO, MnO, WO^2).

Ilvaite (CaO, FeO, Fe^2O^3, SiO^2).

Orthite (CaO, CeO, FeO, Al^2O^3, SiO^2).

Wolfram is at once distinguished by its high sp. gr. which exceeds 7, whilst in *Ilvaite* (= Lievrite Yenite) and in *Orthite* (= *Cerine, Allanite*) the sp. gr. does not exceed 4, or 4·1. The two latter minerals also leave a silica skeleton in phosphor salt BB, whereas *Wolfram* dissolves entirely by fusion in that reagent. For other characters see under

Wolfram in Table III. *Ilvaite* is commonly in black columnar or fibrous masses, or in prismatic crystals, longitudinally striated, and terminated by the planes of a rhombic pyramid. *Orthite* much resembles *Ilvaite*, but the crystals are Clino-Rhombic and the streak is but lightly coloured. Both are easily decomposed, with gelatinization, by hydrochloric acid.

⁂ See also *Schorl* and other dark minerals in Table X.

SECOND GROUP: *Magnetic before or after ignition. Infusible, or fusible only on thinnest edges.*

Magnetic Iron Ore (Fe 72·4, O 27·6).

Franklinite (FeO, MnO, ZnO, Fe^2O^3).

Chronic Iron Ore (FeO 32, Cr^2O^3 68).

Ilmenite (Fe^2O^3, Ti^2O^3).

Hematite ($Fe^2O^3 = Fe$ 70).

Limonite (Fe^2O^3 85, H^2O 15).

For more complete reference to these minerals, consult Table III. Briefly, their more distinctive characters are as follows:—*Streak, black*:—*Magnetic Iron Ore = Magnetite* (strongly magnetic; sp. gr. 4·9 to 5·2). *Franklinite* (strong Mn-reaction with carb. soda BB; sp. gr. 5 to 5·2) *Chromic Iron Ore* (Emerald-green glass with borax BB; sp. gr. 4·5). *Ilmenite* (Hydrochloric acid solution becomes violet-coloured by boiling with metallic tin or zinc; sp. gr. 4·6 to 5·3). *Streak, dull-red*:—*Hematite* (= Red Iron Ore, commonly in fibro-botryoidal masses; sp. gr. 4·9 to 5·2). *Streak, brownish-yellow*: *Limonite* (= Brown Iron Ore). Yields water on ignition. In the outer flame, BB, becomes red;

in the inner flame, becomes black and magnetic. Occurs commonly in fibro-botryoidal masses, often with silky lustre.

THIRD GROUP: *Infusible. Not magnetic after ignition.*

Psilomelane (Mn^2O^3, MnO, Bao, K^2O, H^2O).

Pitchblende (UO, U^2O^3, but rarely pure).

Gadolinite (YO, CeO, BeO, FeO, SiO^2).

Rutile, some examples (TiO^2).

Psilomelane and *Pitchblende* are black, with black or dark brown streak, and they occur in granular and other uncrystallized examples. Both, as a rule, yield a little water on ignition. *Psilomelane* is readily distinguished by the strong manganese-reaction which it gives by fusion with carb. soda, sp. gr. 3·7 to 4·6. *Pitchblende* (= Uran Blende, Nasturane, Uraninite) forms by fusion with phosphor-salt in the R. F. an emerald green glass, the colour deepening as the glass cools. Its high sp. gr., exceeding 6.4, is also characteristic.

Gadolinite is also black or greenish-black in colour, but its streak is greenish-grey. It occurs chiefly in small nodular masses without distinct cleavage; more rarely in small crystals of the Rhombic or Clino-Rhombic system. H 6·5 to 7; sp. gr. 4 to 4·3, BB, generally swells up more or less, and sometimes emits a vivid gleam, but remains unfused. Readily decomposed, with gelatinization, by hydrochloric acid.

Rutile occurs chiefly in red or red-brown square-prismatic crystals which are often geniculated. The streak is comparatively pale. Fused in powder with borax, it forms in the R. F. a dark violet-brown glass which becomes coated over, when flamed, with a light blue or blueish-white film.* sp. gr. 4·2 to 4·3.

⁂ The rare Titanates and Tantalates, *Æschynite*, *Mengite*, *Polymignite*, *Tantalite*, *Columbite*, *Samarskite*, *Yttrotantalite*, &c., also belong to this Table. They are mostly black in colour, with blackish-brown streak or powder. See the author's *Blowpipe Practice*, pages 126, 127.

TABLE X.

[Lustre non-metallic. Hardness sufficient to scratch glass. Streak uncoloured or indistinctly coloured. Fusible. Black or dark-coloured, opaque minerals.]

The representatives of this Table (the phosphate, *Triplite* excepted) consist of comparatively hard, fusible Silicates. By fusion, therefore, with phosphor-salt on platinum wire, all but the above-named phosphate leave an undissolved silica-skeleton in the glass. This is best seen whilst the glass is hot. In some cases, identification requires the aid of crystallization characters. In all the species, the sp. gr. exceeds 3.

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[*] This very striking reaction might be termed, technically, the "cataract-eye test," as the bead resembles an eye affected by cataract. It results from the partial conversion of the Ti^2O^3 into [illegible] as explained by Berzelius, who first described it. To show it properly, the glass must be saturated.

First Group:—*Dissolved or attacked, in powder, by hydrochloric acid.**

Triplite. (Essentially MnO, FeO, P^2O^5).

Orthite or Allanite. (CaO, CeO, FeO, Al^2O^3, SiO).

Titanite or Dark Sphene. (CaO, TiO_2, SiO^2).

Triplite occurs in dark-brown lamellar masses with yellowish-grey streak. Sp. gr. 3·6 to 3.9. BB easily fusible into a dark globule, and forming a turquoise-enamel with carb-soda. Its solution in nitric acid gives a canary-yellow precipitate with amm. molybdate.

Orthite and *Titanite* are distinguished from the above by leaving a silica-skeleton when fused with phosphor-salt.

Orthite is readily decomposed with gelatinization by hydrochloric acid. It occurs chiefly in columnar and granular examples, and also in Clino-Rhombic crystals, of a black or brownish-yellow colour. Sp. gr. 2·8 to 3·8. Easily fusible into a dark and generally magnetic globule.

Titanite is but slightly attacked by hydrochloric acid, but if in sufficiently fine powder enough is generally dissolved to yield the characteristic titanium reaction (a violet coloration) when the solution is boiled with a piece of tin. Commonly in cleavable masses, or in flat, wedge-like crystals, of a dark-brown colour. Average sp. gr. 3·5. BB becomes yellowish, and melts into a dark enamel.

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* Reduce a fragment to fine powder, first by hammer and anvil (or small steel mortar), and then in the agate mortar. Place some of the powder in a test-tube or porcelain capsule with attached handle, cover it with acid, and boil gently for a few minutes. Then add a little distilled water, decant carefully, or filter, neutralize with ammonia, and test with sodium carbonate. If no precipitate ensue from one or the other of these reagents the mineral will not have been attacked. If the trial be made in a test-tube, the tube must be held somewhat aslant, so as to bring the upper portion of the acid under the more immediate influence of the flame, otherwise some of the acid may be projected out of the tube. In inserting the powdered mineral, a long slip of glazed paper, folded gutter-wise, may be conveniently used.

⁂ Some varieties of Garnet are also partially attacked (in fine powder) by hydrochloric acid. See under Group 2, below.

Second Group :—*Decomposed after fusion by hydrochloric acid, the silica gelatinizing on evaporation of the solution.*

Garnet (Dark varieties : CaO or MgO or FeO or MnO ; Al^2O^3 or te^2O^3 or Cr^2O^3 ; SiO^2).

Vesuvian or Idocrase (Essentially, CaO, Mgo, Al^2O^3, Fe^2O^3, SiO^2).

Epidote or Pistazite (Essentially, CaO, Al^2O^3, Fe^2O^3, SiO^2).

These minerals in many cases can only be distinguished by their crystallization, or by a complete quantitative analysis. *Garnet* (which includes several very distinct varieties or sub-species) when crystallized is almost invariably in rhombic dodecahedrous or trapezohedrous, or combinations of these ; dark-red, red-brown, dark-green, black, &c., in colour : light-coloured varieties come under Table XI. Hardness 6·5 to 7·5 ; sp. gr. 3·15 to 4·3. Cleavage indistinct. Fusible, as a rule, with very slight bubbling. *Vesuvian* occurs in Tetragonal crystals, combinations of square prisms and pyramids, and also in granular and columnar masses. Cleavage prismatic, but not very distinct, H 6·5 ; sp. gr. 3·3 to 3·5. Fusible, with more or less bubbling. *Epidote* is Clino-Rhombic in crystalization ; the crystals are essentially prismatic and transversely elongated, with distinct cleavage in two directions, meeting at angle of 115° 24', H 6 to 7; sp. gr. 3·3 to 3·5. BB, expands into a dark cauliflower-like slag or glass. Very easily decomposed by fusion with phosphor-salt.

THIRD GROUP: *Not attacked by hydrochloric acid.*

Augite or Dark Pyroxene (CaO, MgO, FeO, SiO^2).

Hornblende or Dark Amphibole (CaO, MgO, FeO, SiO^2).

Acmite (Na^2O, Fe^2O^3, SiO^2).

Hypersthene (MgO, FeO, SiO^2).

Schorl or Black Tourmaline (Essential components: MgO, FeO, Al^2O^3, B^2O^3, SiO^2).

Cerine (Variety of Orthite: CaO, CeO, FeO, Al^2O^3, SiO^2).

Pitchstone and some Obsidians (K^2O, Na^2O, FeO, Al^2O^3, SiO^2).

Augite and *Hornblende* are closely related silicates, possessing the same general composition, and crystallizing equally in the Chino-Rhombic system. But in *Augite*, the cleavage angle equals 87°6; and in *Hornblende*, 124°30. The common crystals in dark *Augite* are eight-sided prisms, with two sloping planes or one large plane at the top; and in *Hornblende*, six-sided prisms with three rhomb-shaped planes at the extremities. Fibrous, cleavable-lamellar, and granular varieties are also of common occurrence in both species. The usual colours are black, blackish-brown, and very dark green. Sp. gr. 3·0 to 3·4. Easily fusible into a dark magnetic globule. Very slowly attacked, BB, by phosphor-salt.

Acmite is a related augitic species, occurring in long, flattened prisms of a black or brownish-black colour, in quartz. H 6 to 6·5 ; sp. gr. 3·5. Easily fusible into a magnetic bead.

Hypersthene is another closely related ferro-magnesian silicate, but regarded as Ortho-Rhombic in crystallization. It occurs commonly in laminated masses of a dark-green, brown, or greenish-black colour, with bronze-like or metallic pearly lustre. H 6 ; sp. gr. 3.4. Very easily cleavable in one direction. Readily fusible. *Enstatite* (Table XII.) and *Bronzite* (Table XX.) are very closely related to *Hypersthene*, but are very difficultly fusible, and *Bronzite* is comparatively soft.

Schorl is usually in nine-sided or three-sided (more rarely in six-sided) black prisms, with three planes at the top. Also in columnar and fibrous examples. Sp. gr. 3·0 to 3·2 ; hardness equal to that of quartz. Easily fusible with bubbling into a dark (commonly magnetic) bead, and readily decomposed by fusion with phosphor-salt.

Cerine occurs in black granular masses without distinct cleavage. BB, swells up and fuses easily. Sp. gr. usually about 3·5 or 3·7. *Pitchstone* and dark *Obsidian* are also very easily fusible, but are readily distinguished by their low sp. gr. (2·2 to 2·4), as well as by their resino-vitreous lustre and amorphous structure. In *Obsidian*, the fractured surface shows conchoidal markings, and the fragments are sharp edged like broken bottle-glass. See also Table XI., Group 6.

TABLE XI.

[Lustre non-metallic. Hardness sufficient to scratch glass. Streak uncoloured. Fusible. Colourless, or of light, clear tint ; never opaque-black or brown].

FIRST GROUP : *Imparting a green or red colour to the point or margin of the blowpipe-flame.*

Axinite (CaO, MnO, Fe^2O^3, Al^2O^3, B^2O^3, SiO^2).

Boracite (MgO, B^2O^5, $MgCl^2$).

Datolite (CaO, H^2O, B^2O^3, SiO^2).

Botryolite (CaO, B^2O^3, SiO^2, H^2O).

Spodumene (Li^2O, Al^2O^3, SiO^2).

Petalite (Li^2O, Na^2O, Al^2O^3, SiO^2).

Axinite, Boracite, Datolite and *Botryolite* impart a green colour to the blowpipe-flame. The other minerals of this group colour the flame more or less distinctly red.

Axinite occurs in very flat, sharp-edged, vitreous crystals of a violet-brown, grey, green or other colour, about equal in hardness to quartz, sp. gr. 3·3. In the outer flame the fused bead is generally black from the presence of manganese, but it becomes green and translucent after exposure to the inner flame. *Boracite* occurs commonly in small, colourless or lightly-tinted crystals (chiefly combinations of cube and tetrahedron, or rhombic dodecahedron, cube, and tetrahedron) imbedded in anhydrite or gypsum. Very hard ($H = 7$) ; sp. gr. 2·9 to 3·0. Gives chlorine reaction (*i. e.*, azure coloration of flame) when fused with phosphor-salt and copper-oxide. *Datolite* occurs commonly in groups of small vitreous crystals, yielding on ignition a small amount of water (5½ per cent.), and gelatinizing in hydrochloric acid, H 5 to 5·5; sp. gr. 2·8 to 3·0. *Botryolite* occurs in fibro-botryoidal masses which yield on ignition 16 per cent. of water; other characters as in *Datolite.* Both are colourless or light-green, pale-reddish, &c.

Spodumene colours the flame vividly red; *Petalite,* somewhat less distinctly, and the coloration does not always come out immediately. *Spodumene* is mostly pale-green or greenish-white, and *Petalite* reddish-white. Both occur essentially in cleavable lamellar masses. In *Spodumene,* the cleavage angles equal 87° and 133°30'; H 6·5 to 7; sp. gr. 3·1 to 3·2. In *Petalite,* the cleavage angles equal chiefly 117° and 141°23'; H 6 to 6·5; sp. gr. 2·4 to 2·6. *Spodumene,* BB, swells up and fuses with much bubbling; *Petalite,* fuses without intumescence.

SECOND GROUP:—*Yielding water on ignition in the bulb-tube.*

Prehnite (CaO, Al^2O^3, SiO^2, H^2O 4 %).

Analcime (Na^2O, Al^2O^3, SiO^2, H^2O 8 %).

Natrolite (Na^2O, Al^2O^3, SiO^2, H^2O 9½ %).

Thomsonite (Na^2O, CaO, Al^2O^3, SiO^2, H^2O 13 %).

Scolezite (CaO, Al^2O^3, SiO^2, H^2O 14 %).

Chabazite (K^2O, CaO, Al^2O^3, SiO^2, H^2O 21 %).

Apophyllite (KF, CaO, SiO^2, H^2O 16 %).

These minerals occur essentially in association with trappean or basaltic rocks, filling amygdaloidal cavities in these, or occasionally forming small strings or veins. *Prehnite* scratches glass strongly, and yields as a rule little more than traces of water on ignition. H. 6 to 8; sp. gr. 2·8 to 3. Fusible with intumescence or continuous bubbling. See under Group 4, below.

The other species of this group scratch glass very slightly, and in some examples not at all: hence they belong properly to Table XVIII, but to prevent risk of error in their determination, they are referred to, also, here.

Analcime and *Natrolite*, fuse without intumescence and colour the flame strongly yellow. Their ignition-loss is below 10 per cent. *Analcime* is mostly in trapezohedrons and trapezohedrally modified cubes, *i. e.*, with three small planes at each angle. Colourless, opaque-white, pale reddish, &c. H 5·5; sp. gr. 2·1 to 2·3. Decomposed, without gelatinizing, by hydrochloric acid. *Natrolite* (= *Mesotype* in part) occurs in acicular groups and small rhombic crystals, but more commonly in light brownish-yellow radio-fibrous masses. H 5 to 5·5; sp. gr. 2·17 to 2·27. Gelatinizes in hydrochloric acid.

Thomsonite, *Scolezite*, *Chabazite*, and *Apophyllite*, fuse with more or less strongly marked intumescence, and their ignition-loss always exceeds 12 per cent.—varying from 13 per cent. in *Thomsonite*, to 21 per cent. in *Chabazite*. *Thomsonite* (= *Comptsonite*) occurs in rectangular (nearly square) prisms, and in acicular and fibrous examples. H 5 to 5·5; sp. gr. 2·3 to 2·4. *Scolezite* (although Clino-Rhombic in crystallization) much resembles *Thomsonite* in general characters, but is distinguished (at least in typical examples) by its more marked intumescence on ignition,—the test-fragment expanding and throwing out worm-like excrescences on the first application of the flame. Both gelatinize in hydrochloric acid. *Chabazite* is readily distinguished by its occurrence in small, obtuse rhombohedrons,—or, exceptionally (*Phacolite*), in twelve-sided, flat pyramids, frequently lenticular from distortion. H 4 to 5; sp. gr. 2 to 2·2. Decomposed, without gelatinizing, by hydrochloric acid. *Apophyllite* or *Ichthyopthalmite* differs from the other species of this group in not containing alumina. Hence, its hydrochloric acid solution — after separation of the silica by evaporation, moistening the dry residuum with hydrochloric acid, and redissolving soluble matters in water—does not yield a precipitate with ammonia. It occurs chiefly in modified square-prisms and acute pyramids with strongly-marked basal cleavage,—the basal plane and cleavage plane being always pearly, and generally more or less iridescent, whilst the other planes are vitreous in lustre. Sp. gr. 2·3 to 2·4. BB, exfoliates and melts with bubbling.

⁂ The following species may also be referred to this group:—*Faujasite*, *Gismonaine*, *Zeagonite*, *Okenite*, *Brewsterite*, *Pectolite*. See the author's BLOWPIPE PRACTICE, Table XXVII. *Harmotome* and *Phillipsite*, which scratch glass very indistinctly, and in some examples not at all, are placed in the present Guide-Book under Table XVIII.

THIRD GROUP: *Not yielding water on ignition. Giving sulphur-reaction BB with carb. soda,* or chlorine-reaction with phosphor-salt and copper oxide.†*

Hauyne (K^2O, Na^2O, CaO, Al^2O^3, SiO^2, SO^3).

Lapis Lazuli Na^2O, CaO, SiO^2, SO^3).

Helvine (BeO, MnO, FeO, SiO^2, $MnFeS$).

Sodalite (Na^2O, Al^2O^3, SiO^2, $NaCl$).

The minerals of this group are comparatively of rare occurrence. All are readily decomposed, with gelatinization, by hydrochloric acid—*Helvine* and many examples of *Lapis Lazuli* giving off during solution an odour of sulphuretted hydrogen.

Hauyne, *Lapis Lazuli* and *Helvine*, give, by fusion with carb. soda on charcoal, a sulphur-reaction. *Hauyne* occurs chiefly in grains or small crystals (rhombic dodecahedrons) of a blue or blueish-green colour. It is rather difficulty fusible. *Lapis Lazuli* occurs chiefly in granular masses of a rich blue colour, often intermixed with calcite and pyrites; also crystallized at times in the form of the rhombic dodecahedron, H 5·5; average sp. gr. 2·4. Easily fusible.

Helvine occurs mostly in small tetrahedrons of a dull-yellow or greyish-red colour, H 5·5 to 6·5; BB, fuses before the flame-point into a dark bead, which becomes yellow in a reducing flame. With carb. soda, gives a deeply-coloured turquoise-enamel. *Danalite* is a flesh-red, zinc-holding *Helvine.*

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* The test-matter in powder is mixed with two or three times its volume of carb. soda, and fused on charcoal in a reducing flame—a candle or oil-lamp (not a gas flame) being used for the fusion. The fused slag is then removed by a knife-point and placed with a drop of water on a silver coin. The latter is stained brown or black. The stain may be removed by rubbing with moistened bone-ash.

† The test-matter added to a fused bead of phosphor-salt coloured deep-green or blue by a few particles of black copper-oxide, is exposed to the point of an oxidating flame. This assumes a vivid blue colour.

Sodalite occurs in small, colourless (or more rarely blue or green), dodecahedral crystals and vitreous grains, and thus closely resembles *Hauyne* in general aspect, but is distinguished by giving chlorine-reaction (*i. e.*, azure coloration of flame-point) by fusion with phosphor-salt and copper oxide.

FOURTH GROUP:—*Decomposed or attacked, in powder, by hydrochloric acid.*

Sphene (CaO, MnO, TiO^2, SiO^2).

Nepheline (K^2O, Na^2O, Al^2O^3, SiO^2).

Wollastonite (CaO, SiO^2).

Prehnite (H^2O, CaO, Al^2O^3, SiO^2).

Wernerite or *Scapolite* (CaO, Al^2O^3, SiO^2).

Anorthite (CaO, Al^2O^3, SiO^2).

Labradorite (Na^2O, CaO, Al^2O^3, SiO^2).

Sphene is only partially attacked, in fine powder, by hydrochloric acid, but the partial solution boiled with a piece of tin gradually assumes a violet colour. The sp. gr. of *Sphene* exceeds 3·3, whilst that of the other minerals of this group is under 3. The light-coloured *Sphenes* are principally green, yellow or grey, and they occur commonly in Clino-Rhombic crystals (frequently twinned), and in cleavable lamellar masses. Sp. gr. 3·4 to 3·6. BB fusible with bubbling into a dark enamel. See also under *Titanite* in Table X.

Nepheline and *Wollastonite* gelatinize with hydrochloric acid. *Nepheline* occurs in hexagonal prisms and lamellar masses either colourless, or pale-brown, &c., with vitreous lustre; or grey-blue, blueish-green, and red, with vitreo-resinous aspect (*Elæolite*). Sp. gr. 2·5 to 2·7. Easily fusible with more or less bubbling. *Wollastonite* is chiefly in colourless, pale-reddish, or yellowish fibrous and lamellar masses, with cleavage angles of 84° 30′ and 95° 30′. Scratches glass slightly. Fuses quietly. Sp. gr. 2·7 to 2·9.

Prehnite is chiefly in green or greenish-white (or occasionally pale-red) fibro-botryoidal examples in trap rocks, more rarely in tabular and prismatic crystals.* H = 6 to 7 ; sp. gr. 2·8 to 2·96. Easily fusible with continued bubbling. When strongly ignited in the bulb-tube, it should yield about 4 per cent. water, but in many cases the reaction is very obscure: hence this species is inserted in the present Table. Only in part decomposed by hydrochloric acid, unless previously fused. *Chlorastrolite* is a green variety in small nodules from Lake Superior.

Wernerite or *Scapolite*, *Anorthite*, and *Labradorite*, are decomposed (the latter incompletely), without gelatinizing, in hydrochloric acid

Wernerite is chiefly in short, thick, Tetragonal prisms with pyramidal terminations, or in fibro-lamellar and columnar masses, white, pale-red, greenish, &c., in colour. H 5 to 6 ; sp. gr. 2·6 to 2·8. Fusible with more or less bubbling. *Anorthite* occurs in Clino-Rhombic crystals (often twinned) and in lamellar and granular masses of a white or pale-red colour, with cleavage-angles of 85°50' and 94°10'. H 6; sp. gr. 2·6 to 2·8. Fusible quietly, but on the edges only, unless in thin, pointed splinters. *Labradorite* occurs essentially in cleavable lamellar masses, mostly light-grey or white in colour, with (in typical examples) reflected tints of blue, green, violet, or orange. Cleavage-angles, 86°40' and 93° 20'. Otherwise much like *Anorthite*, but more easily fusible.

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* See a synopsis of the typical *Prehnite* crystals, in the author's Blowpipe Practice and Mineral Tables, page 275.

FIFTH GROUP: *Decomposed by hydrochloric acid only after fusion.*

This group is chiefly represented by light-coloured varieties of the species described under Group 2 of Table X. In testing their solubility, three or four fused beads should be prepared, and these must be reduced to fine powder, first in a steel mortar (or by the hammer and anvil, under a slip of paper) and then in the agate mortar. On the solution being slowly evaporated, the silica separates in a gelatinous condition. The sp. gr. of the included minerals exceeds 3.

Garnet (CaO, MgO, FeO, MnO, Al^2O^3, SiO^2).

Idocrase or Vesuvian (CaO, &c., Al^2O^3, SiO^2).

Epidote CaO, Al^2O^3, Fe^2O^3, Mn^2O^3, SiO^2).

Zoizite (CaO, Al^2O^3, SiO^2).

See, also, *Prehnite* in the preceding group.

Garnet may usually be distinguished by its occurrence in rounded grains or crystals of the Regular System (rhombic dodecahedron and trapezohedron)—the other minerals of the group affecting prismatic forms and fibrous or columnar aggregations. *Idocrase* is Tetragonal in crystallization; *Zoizite*, Rhombic; and *Epidote*, Clino-Rhombic (See the preceding Table, Group 2). The principal varieties of *Garnet* referable to the present group, include the red, pink and light brown *common Garnets* (*Aplome* and *Almandine* in part, *Hessonite*, &c.), the yellow *Topazolite* and the light-green *Grossular*. *Idocrase* or *Vesuvian* can hardly be distinguished, except by its Tetragonal crystallization, from many garnets. It fuses, however, with considerable bubbling, whilst most garnets fuse more or less quietly or with only slight bubbling. In both, the average sp. gr. equals 3·3 or 3·4 (as regards light-coloured examples). H in *Vesuvian*, 6·5; in *Garnet* 7 to 7·5. The common colours of *Vesuvian*, are clear red, yellowish-brown, green, &c.

Epidote and *Zoizite* curl up or expand into a cauliflower-like mass on the first application of the flame, and afterwards fuse into a slag or glass, which is usually dark in colour in *Epidote*, and colourless in *Zoizite*. *Epidote* occurs in fibrous and columnar masses and in transversely elongated prismatic crystals of a green or yellowish-brown tint. Sp. gr. 3·3 to 3·5; H 6 to 7. *Zoizite* is commonly in light-grey, greenish-white, or reddish, sub-columnar and bladed masses. H 6; sp. gr. 3·2 to 3·4. Cleavage strongly marked in one direction. In *Epidote* there are two easy cleavages, meeting at angle of 115°24'. The light grey colour and bladed structure of typical examples of *Zoizite* serve, as a rule, to distinguish the two species.

SIXTH GROUP:—*Not attacked by hydrochloric acid.*

(See the directions given in the foot-note to Table X.)

Rhodonite (MnO, SiO^2,—part of MnO commonly replaced by CaO, &c.)

Diopside or *Light-coloured Pyroxene* (CaO, MgO, SiO^2).

Tremolite or *Light-Coloured Amphibole* (MgO, CaO, SiO^2).

Enstatite (Mgo, SiO^2).

Orthoclase (K^2O, Al^2O^3, SiO^2).

Albite (Na^2O, Al^2O^3, SiO^2).

Obsidian (K^2O, Na^2O, Al^2O^3, SiO^2).

Rhodonite is at once distinguished by the strong manganese-reaction which it gives with borax or carb-soda before the blowpipe, and by fusing *per se* into a dark-red or amethystine glass which becomes black and opaque in the outer flame. It occurs chiefly in red, cleavable masses, weathering dark-brown. H 5 to 5·5; sp. gr. 3·5 to 3·65.

Diopside and *Tremolite* are very commonly in fibrous and acicular examples, a condition never presented by *Orthoclase* or *Albite.* They are also more easily fusible than these latter minerals, which, as a rule, unless in very thin splinters, melt on the edges only. Their colour is commonly white, pale-grey, greenish-white or light-green,—varieties of the latter colour (= *Green Diopside*, *Sahlite*, *&c.*, and *Actynolite* forming, respectively, a connecting link to *Augite* and *Hornblende.* In *Diopside* crystals, the prism-angle equals 87° 6; and in *Tremolite* and *Actynolite*, the same angle equals 124° 30′. In lamellar examples, the cleavage angles are identical with these.* H 5·5 to 6; sp. gr., in *Diopside*, 3 to 3·4; in *Tremolite* 2·9 to 3·3. Both fuse, in thin splinters, with slight bubbling.

Enstatite is a kind of rhombic, non-calcareous pyroxene. In ordinary examples it cannot properly by distinguished from the latter, except by its difficult fusibility. It presents a green or greenish-grey colour, and occurs in cleavable masses and occasionally in rhombic crystals. H nearly 6; sp. gr. 3·1 to 3·3. Fusible only when in very fine splinters.

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* A synopsis of the crystal types of *Pyroxene* and *Amphibole* will be found in the Mineral Tables (pages 250 to 252) forming Part II. of the author's "Blowpipe Practice."

Orthoclase, commonly known as "Potash Feldspar," and *Albite* or "Soda Feldspar," occur chiefly in crystals (often large and rough) and in cleavable, lamellar masses of a white, red, grey, or light-green colour, easily distinguished from cleavable light-coloured Pyroxenes and Amphiboles by their lower sp. gr., which is always under 2·7. *Orthoclase* is Clino-Rhombic in crystallization, and its cleavage planes (which are generally somewhat pearly) meet at right angles. Sp. gr. 2·5 to 2·6. *Albite* is Triclinic or Anorthic in crystallization, and its cleavage planes meet at angles of 86°24' and 93°36'.* Sp. gr. 2·6 to 2·65. Both *Orthoclase* and *Albite* are difficultly fusible unless in fine splinters, and they are thus constantly regarded as infusible by students who have had but little practice in blowpipe work, or who presist in using fragments of unsuitable size. Both scratch glass strongly (H = 6).

Obsidian is easily recognized by its occurrence in amorphous sharp-edged masses, somewhat resembling bottle-glass, of a grey, greenish, brown, black, or other colour. H 6 to 7; sp. gr. 2·2 to 2·4. Shews conchoidal fracture, and is readily fusible.

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* See conspectus of the crystal types of *Orthoclase* and *Albite*, in the author's "Blowpipe Practice and Mineral Tables," pages 253 to 255.

TABLE XII.

[Minerals of non-metallic lustre and uncoloured streak. Hard enough to scratch glass. Infusible, or fusible on thinnest edges only.]

First Group: *Yielding water on ignition in the bulb-tube.*

Turquoise or Kalaite (Al^2O^3, P^2O^5, H^2O).
Lazulite (MgO, Al^2O^3, P^2O^5, H^2O).
Diaspore (Al^2O^3, H^2O).
Chloritoid (MgO, FeO, Al^2O^3, SiO^2, H^2O).
Cerite (CeO, SiO^2, H^2O).
Calamine (ZnO, SiO^2, H^2O).

Turquoise, *Lazulite*, *Diaspore*, and *Chloritoid*, scratch glass distinctly; *Cerite* and *Calamine*, more or less feebly or indistinctly.

Turquoise and *Lazulite* are phosphates; their solution in nitric acid gives consequently a canary-yellow precipitate with amm. molybdate. *Turquoise* occurs in light-blue and blueish-green, opaque, uncleavable examples. H 6; sp. gr. 2·6 to 2·8. Blackens on ignition, and yields 20 to 21 per cent. water in the bulb-tube. Many specimens give copper-reactions with borax. *Lazulite* occurs essentially in small, pyramidal crystals of a light-blue colour. H 5·5 to 6; sp. gr. 3 to 3·2. BB, crumbles and tinges the flame-point pale-green, but does not fuse. In the bulb-tube, yields about 6 per cent. water.

Diaspore occurs mostly in white or lightly-tinted foliated, scaly, or broad-fibrous examples: more rarely in rhombic crystals. H 6; sp. gr. 3·3 to 3·5. Decrepitates (as a rule) on ignition, and yields about 15 per cent. water. Assumes a fine blue colour after ignition with cobalt nitrate. Insoluble in acids.

Chloritoid is distinguished by its occurrence in dark-green, foliated and scaly-granular masses, resembling ordinary *chlorite* (Table XX), but differing by its much greater hardness, 5·5 to 6, sp. gr. 3·5 to 3·6. Fusible on thin edges into a black magnetic slag. Decomposed, in powder, by sulphuric acid, but scarcely attacked by hydrochloric acid.

Cerite and *Calamine* are decomposed with gelatinization by hydrochloric acid.

Cerite occurs chiefly in fine-granular masses of a red, brownish, or red-grey colour. H 5 to 5·5; sp. gr. 4·9 to 5·0. BB becomes yellow but does not fuse. In the bulb-tube gives 6 per cent. water. The saturated borax-glass becomes opaque on cooling or when flamed.

Calamine occurs mostly in aggregations of small, vitreous crystals, and in botryoidal and cavernous masses, white, yellowish, or brownish in colour, and sometimes light-blue from presence of a small amount of copper oxide. Scratches glass very feebly, in some cases not at all; hence belongs properly to Table XX, which see. The saturated borax-glass becomes opaque on cooling or when flamed; and when crushed and mixed with some carb. soda, it gives on charcoal, in a good reducing flame, a zinc sublimate,—lemon-yellow whilst hot, white when cold, and light-green after ignition with cobalt solution. In the bulb-tube, *Calamine* yields 7·5 per cent. water. Sp. gr. 3·3 to 3·5.

SECOND GROUP: — *Anhydrous (or practically anhydrous) species. Decomposed in powder by hydrochloric acid, the silica separating (on partial evaporation of the solution) in a gelatinous state.*

Willemite (ZnO, SiO^2).
Troostite (ZnO, MnO, FeO, SiO^2).
Chrysolite or *Olivine* (MgO, FeO, SiO^2)
Chondrodite ($MgFl^2$, MgO, FeO, SiO^2).
Gehlenite (CaO, MgO, $Al\,O^3$, SiO^2).

Willemite and *Troostite* when fused with a mixture of carb. soda and borax in a good reducing flame on charcoal, deposit on the support a sublimate of zinc oxide, lemon-yellow whilst hot, and white when cold. Moistened with a drop of cobalt nitrate, and again ignited, the sublimate on cooling becomes light-green. Fused with borax on platinum wire, both form a glass which on saturation becomes opaque by flaming or when cold. *Willemite* is mostly in very small rhombohedral crystals with rounded edges; whilst *Troostite* (properly a manganese-holding variety of *Willemite*) is generally in opaque or semi-opaque crystals (hexagonal prisms with rhombohedral terminations) of medium size. Both are white, yellowish-grey, brownish, &c. H 5·5; sp. gr. 3·9 to 4·2; infusible, or vitrifying on thin edges only.

Chrysolite, Chondrodite and *Gehlenite* scratch glass strongly. The common variety of *Chrysolite*—the only one likely to come under ordinary observation—is known as *Olivine.* This occurs chiefly in small, vitreous, granular examples of a bottle-green or yellowish-brown colour, in basaltic rocks. *Chrysolite* proper is in small prismatic crystals of a pale-yellow or greenish-yellow colour. H 6·5 to 7; sp. gr. 3·2 to 3·5. *Chondrodite* occurs mostly in small, yellow, greenish, or yellowish-brown, granular masses, in crystalline limestone. H 6 to 6·5; sp. gr. 3 to 3·3. Practically, infusible. In powder, with concentrated sulphuric acid, gives fluorine reaction—*i. e.*, it emits fumes which corrode glass. *Gehlenite* occurs chiefly in square prisms of small size, greenish-grey, green or brownish in colour. H 5·5 to 6; sp. gr. 3·1. BB, rounded on thin edges.

THIRD GROUP:—*Dissolved or decomposed in powder, without gelatinizing, by hydrochloric acid.*

Zinc Spar (ZnO, CO^2).

Apatite ($CaO, P^2O^5, Ca [Cl, F]^2$).

Leucite (K^2O, Al^2O^3, SiO^2).

Zinc Spar and *Apatite* scratch glass very feebly or indistinctly, and in many examples do not scratch glass at all. Hence these minerals belong properly to other Tables. *Zinc Spar* is especially distinguished by effervescing in acids and by giving a sublimate of ZnO (lemon-yellow whilst hot, and white when cold) by fusion in a reducing flame on charcoal with a mixture of carb. soda and borax: See Table XV.—*Apatite* occurs chiefly in hexagonal crystals and in granular and cleavable masses of a green, greenish-white, or brownish red colour. Fine splinters vitrify at the extreme point in a well-sustained flame. The solution in nitric acid yields a canary-yellow precipitate with amm. molydate. See Table XX., Group 2.

Leucite, as a rule, is readily distinguished by its occurrence in trapezohedrons (or pseudo-trapezohedrons), or in small granular masses, in lava. Its colour is white, pale-yellowish or light-grey. H 5·5 to 6; sp. gr. 2·45 to 2·5. Infusible.

FOURTH GROUP: *Forming BB with borax in the R. F. a dark violet-brown glass which (when saturated) becomes coated by flaming with a light-blue film.**

Rutile (TiO^2).

Anatase or Octahedrite (TiO^2).

Brookite (TiO^2).

(*Arkansite* = Ferruginous Brookite).

These minerals can only be distinguished individually by crystallization and general aspect. In all, the lustre is adamantine, approaching sub-metallic. *Rutile* is commonly dark-red with indistinctly light-brown streak; and is usually in square-prismatic crystals, longitudinally striated, and very frequently twinned so as to present a geniculated aspect. It occurs also in the form of opaque, dark pebbles, a variety known as *Nigrine*. H 6 to 6·5; sp. gr. 4·2 to 4·3.

Anatase or *Octahedrite* is indigo-blue, brown, or yellowish-grey in colour; and it occurs always in acute square-based pyramids, of small size but very distinctly formed. H 5·5 to 6; sp. gr. 3·8 to 4. *Brookite* occurs in rhombic crystals, commonly more or less tabular, of a light-brown or light yellowish-red colour; but is sometimes black and opaque, as in the variety *Arkansite*. H 5·5 to 6; sp. gr. 4 to 4·3.

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* See foot-note to group 3, TABLE IX.

FIFTH GROUP: *Yielding metallic globules, BB, with reducing flux on charcoal.*

Cassiterite or Tinstone (SnO^2).

This mineral, the common ore of tin, is the only representative of this group. It is easily recognized by its high sp. gr. (6·7 to 7), combined with its stony aspect and great hardness (6 to 7); as well as by the malleable metallic globules obtained from it by blowpipe treatment with reducing flux on charcoal. It may be reduced indeed *per se* (although quite infusible), but a well-sustained blast is required for the purpose. With a mixture of carb. soda and a little borax, or carb. soda and cyanide of potassium (the latter reagent, it must be remembered is a highly poisonous substance), or with neutral oxalate of potash, the reduction is very easily effected. *Cassiterite* occurs principally under two forms: in small crystals of the Tetragonal System (mostly combinations of square prism and pyramid, often twinned or geniculated), and in small pebbles known as "stream tin" from their occurrence in alluvial deposits. Occasionally, also, it is found in massive examples of radio-concentric structure known as "toad's-eye tin" and "wood tin." Commonly, dark or light-brown, black, reddish, &c.; more rarely, colourless.

SIXTH GROUP: *Reactions of preceding groups not manifested. Specific gravity exceeding* 3.

Zircon (ZrO^2, SiO^2).

Corundum (Al^2O^3).

Chrysoberyl (BeO, Al^2O^3).

Spinel (MgO, Al^2O^3).

Gahnite (ZnO, Al^2O^3).

Pleonaste (MgO, FeO, Al^2O^3).

Diamond (C).

Topaz (Al^2O^3, SiO^2, Fl).

Staurolite (FeO, MgO, Al^2O^3, SiO^2).

Cyanite Al^2O^3, SiO^2).

Andalusite (Al^2O^3, SiO^2).

Uwarowite (*Chrome Garnet*: CaO, Al^2O^3, Cr^2O^3, SiO^2).

Tourmaline (MgO, Al^2O^3, B^2O^3, SiO^2).

These minerals may be subdivided into lesser groups in accordance with their specific gravity. In *Zircon*, *Corundum*, *Gahnite*, and *Pleonaste* (the two latter commonly regarded as varieties or sub-species of Spinel), the sp. gr. equals or exceeds 3·9 or 4. *Zircon* occurs in Tetragonal crystals (and occasionally in rounded grains) of a dark or light red, brown, yellow, yellowish-grey or other colour, rarely colourless. The crystals are commonly square prisms combined with a square pyramid or with several pyramids. H 7·5 ; sp. gr. usually about 4·4. BB, in powder, slowly dissolved by borax, the saturated glass becoming opaque when flamed. *Corundum* is the hardest of all known minerals, the diamond excepted. It represents three more of less distinct varieties: *Noble Corundum*, *Adamantine Spar* and *Emery*. The first occurs in small transparent or translucent crystals and rolled pebbles of a blue, red, white, or other tint—two colours, as blue and white, being often present together in the same example. The crystals are chiefly acute hexagonal pyramids, sometimes with large vasal plane, but are frequently ill-shaped. Blue examples form the *Sapphire*, and red examples the *ruby* of jewellery. *Adamantine Spar* is a coarser variety in translucent or opaque crystals and cleavable examples of a greenish-white, dull-green, red, brownish, or other colour. The cleavage is rhombohedral and also basal, and some of the cleavage planes shew a delicate cross-striation. The sp. gr. of these varieties averages 4, but oscillates between 3·91 and 4·16. The third variety, *Emery*, occurs in granular masses of a grey, dull-blue, or black colour, dark examples being often mixed with magnetic iron ore. When fused in fine powder with potassium bisulphate, *Corundum* becomes soluble in water. From the solution, ammonia precipitates gelatinous Al^2O^3, often tinted brown by accompanying Fe^2O^3.

Gahnite and *Pleonaste* occur in dark-green or black opaque octahedrons, often twinned. *Gahnite* gives a sublimate of ZnO, when fused on charcoal with a mixture of carb. soda and borax. H 8 ; sp. gr. 4·3 to 4·9. *Pleonaste* is a *ferruginous spinel*, distinguished from the *zinc spinel*, *Gahnite*, by its lower sp. gr. (which does not exceed 4), and also by not yielding a sublimate with reducing agents on charcoal.

The second sub-group, with sp. gr. between 3·5 and 3·75, comprises: *Spinel*, proper, *Chrysoberyl*, the *Diamond*, *Topaz*, *Uwarowite* or *Chrome Garnet*, *Staurolite*, and *Cyanite*. The four last are silicates, and they give a silica-skeleton by fusion with phosphor-salt. *Spinel* occurs as a rule in small octahedrons (often twinned of a red or pale-blue colour. H 8; sp. gr. 3·5 to 3·62. *Chrysoberyl* or *Cymophane*, is a comparatively rare mineral, greenish-white or green in colour, sometimes opalescent, and occurring essentially in small prismatic crystals of the Rhombic system. These are occasionally in stelliform or pseudo-hexagonal twin-combinations. H 8 to 8·5; sp. gr. 3·65 to 3·75. Decomposed by fusion, in fine powder, with potassium bisulphate. The *Diamond* scratches *Corundum*, *Topaz*, and all other bodies. It occurs in small crystals (often with curved planes) of the Regular System—more especially in octahedrons, tetrahedrons, and 48-faced solids or adamantoids, with octahedral cleavage. Colourless, or variously tinted; sometimes black. Sp. gr. 3·5 to 3·55. *Topaz* occurs is prismatic (Rhombic) crystals* and small pebbles of a yellow, yellowish-white, greenish-white or pale-blueish colour, and vitreous lustre, with perfect cleavage in one direction; and also in opaque, pale reddish-white and straw-yellow, columnar and prismatic aggregations (*Pycnite*). H 8; sp. gr. 3·5 to 3.57. The greater hardness and higher sp. gr., as well as the rhombic form when crystallized, serve at once to distinguish it from beryl and quartz. Its almost colourless pebbles are distinguished also from those of quartz by their ready cleavage. *Uwarowite* or *Chrome Garnet*, which differs from ordinary garnets by its infusibility, occurs in small granular examples and microscopic crystals (rhombic dodecahedrons) of an emerald-green colour, mostly imbedded in crystalline limestone. It is comparatively rare, but occurs at several localities in the Province of Quebec. H 7·5; sp. gr. 3·5. With borax and phosphor-salt it forms glasses of a fine green colour, when cold. *Staurolite* occurs chiefly in twinned cruciform crystals, more rarely in simple rhombic prisms, of a dark red or opaque-brown colour, sometimes coated with glistening mica or intimately associated with crystals of blue and white cyanite. H 7 to 7·5; sp. gr. 3·5 to 3·8. The rhombic crystals are commonly six-sided from the replacement of the acute edges. In other respects the species is in general easily distinguished by the remarkable cruciform crystals in which it so commonly occurs. *Cyanite* or *Kyanite* (also known as *Disthene*) occurs chiefly in bladed or fibrous masses, or in long imperfectly formed crystals, of a blueish-white, pale-blue, light-grey, greenish or reddish colour, and somewhat pearly or pearly-vitreous lustre. H, on edges, 7; on flat surface 5 to 5·5. Sp. gr. 3·5 to 3·7. BB, quite infusible.

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* See synopsis of the three leading types of topaz crystals (Brazilian, Siberian, and Saxon) in the Author's MINERAL TABLES, forming Part II. of "BLOWPIPE PRACTICE," page 209.

A third sub-group, with specific gravity below 3·3, comprises *Andalusite* and *Tourmaline*, the black, fusible variety of the latter, known as Schorl, excepted. These give, BB, with phosphor-salt, a silica skeleton. *Andalusite* is commonly in granular masses and in somewhat coarse prisms—apparently square, but actually rhombic, with angles of about 91° and 89°—dull-red, grey, &c., in colour. H (in unaltered examples) 7 to 7·5; sp. gr. 3·1 to 3·2. BB, quite infusible; by ignition in powder with cobalt-solution becomes blue, but this character is common to all the aluminous minerals of this group (*Corundum*, *Chrysoberyl*, *Cyanite*, &c.). The curious mineral *Chiastolite*, is commonly regarded as a variety of *Andalsuite*. It is at once recognized by its peculiar occurrence in slender straw-like prisms scattered through certain clay slates and micaceous schists, or occasionally in thicker cruciformly-arranged prisms, shewing in both cases on the transverse section, a dark cross, or dark lozenge at the centre and angles, composed of intervening rock-matter.

Tourmaline here considered apart from the black, fusible variety, *Schorl*, is usually in triangular or nine-sided prisms of a green, brown, blue, or red colour, sometimes red internally, and green on the outside, in the same specimen. Red, lithia-containing varieties are known as *Rubellite.* The prisms are more or less translucent when viewed transversely, and opaque (even in short pieces) longitudinally. H 7 to 7·5 ; sp. gr. 2·9 to 3·2. Pyro-electric ; BB, practically infusible ; but some examples become slightly blistered on thin edges, and most examples lose their colour. The presence of B^2O^3 is revealed by treating in fine powder with sulphuric acid, evaporating nearly to dryness, and testing on a loop of platinum wire, or in a platinum spoon, in the Bunsen or blowpipe flame ; or by adding alcohol, and inflaming the mixture. The point or border of the flame becomes coloured distinctly green.

SEVENTH GROUP :—*Specific gravity under* 3. *Reactions of preceding groups not manifested.*

The minerals referred to this group comprise the infusible species *Quartz* and *Opal*, in which there is no visible cleavage ; the practically infusible *Iolite* and *Beryl*, with more or less distinct cleavage ; and the difficulty fusible feldspars *Orthoclase* and *Albite*, with strongly pronounced, spathoidal cleavage-planes.

Quartz (SiO^2).

Opal (colloidal SiO^2, usually hydrated).

Iolite (essentially, MgO, FeO, Al^2O^3, SiO^2).

Beryl or *Emerald* (BeO, Al^2O^3, SiO^2).

Orthoclase (essentially, K^2O, Al^2O^3, SiO^2).

Albite (essentially, Na^2O, Al^2O^3, SiO^2).

Quartz and *Opal* break with conchoidal fracture, and are quite infusible. *Quartz* occurs in vitreous masses, and abundantly in hexagonal prisms and pyramids, either colourless, or tinted brown, yellow, violet, rose-red, &c., forming, among others, the varieties known as *Rock-crystal, Smoky Quartz, Cairngorm, Amethyst, and Rose-quartz.* Also in uncrystalline, sub-vitrous, calcedonic varieties, forming *Calcedony* (white, yellowish, blueish, &c.), *Carnelian* (red), *Chrysoprase* (apple-green, the colour due to NiO), *Cat's eye* (yellowish, colourless, green, &c., with floating opalescence), *Heliotrope* or *Bloodstone* (dark-green, often with red-spots), *Agate* and *Onyx* (with banded colours), *Jasper* (opaque red, brown, &c.), *Flint, Hornstone, Chert, &c.*—the latter varieties often forming the petrifying substance of organic remains.

In the crystalline examples, H = 7. It is sometimes a little lower in other varieties, but all scratch glass very strongly. Sp. gr. 2·5 to 2·8, mostly about 2·66. *Opal* occurs only in amorphous masses, commonly in cavities of certain amygdaloidal trap-rocks. H 5·5 to 6·5; sp. gr. 1·5 to 2·5. The leading varieties comprise *Noble Opal, Girasol, Fire Opal* (colourless, pale-blueish, yellowish, with green, blue, red, and other coloured iridescence); *Hyalite* (in colourless botryoidal masses and coatings on lava); *Common Opal, Semi-Opal, Wood-Opal, &c.* (white, brown, blueish, red, yellow, &c., with more or less waxy or sub-resinous aspect). These varieties almost invariably yield a little water by ignition in the bulb-tube; and they are attacked, and wholly or in great part dissolved, when boiled in fine powder with a strong solution of caustic potash.

Iolite (also named *Dichroite* and *Cordierite*) is not very common. It occurs chiefly in small granular examples of a dull-blue, blue-black, or brownish colour, and occasionally in short thick prisms of pseudo-hexagonal aspect. Transparent specimens are dichroic or properly tri-chroic, shewing different tints (blue, pale-brown, yellowish) in different directions. H 6·5 to 7·5 ; sp. gr. 2·5 to 2 7. Infusible, or fusible only on thinnest edges. *Beryl* occurs most commonly in simple or slightly modified hexagonal prisms, and also in masses of columnar and granular structure, greenish-white, pale-green, greenish-blue, emerald-green, or yellow, in colour. The bright green varieties, coloured by a small amount of Cr^2O^3, form the Emerald. H 7 to 7·5 ; specific gravity 2·66 to 2·75. Thin splinters become opaque-white in the blowpipe flame, and frit or fuse slightly at the extreme point ; but unless the test-fragment be very sharply pointed, and the blast be well sustained, very little sign of fusion is produced. Hence the mineral is commonly regarded as infusible.

The feldspars, *Orthoclase* and *Albite*, fuse readily on the edges if tested in the form of thin splinters, and a sharply pointed fragment becomes quickly rounded ; but comparatively thick and square-edged pieces, especially if tried by persons who have had but little practice with the blowpipe, may easily be regarded as infusible. These minerals, therefore, are inserted in both Table XI., and in the present Table,—all risk of error in their determination being thus avoided. They are easily recognized by their broad, smooth cleavage planes. These, in *Orthoclase* meet at 90° and in

Albite at 93°36' and 86°24'. *Orthoclase* is Clino-Rhombic, and *Albite* Triclinic in crystallization, twinned forms in both being common.* White, red, reddish-white, light-green, in colour. H 6; sp. gr. 2·5—2·65. See also, Table XI., Group 6.

TABLE XIII.

[Lustre non-metallic. Hardness insufficient to scratch window-glass. Sapid.]

The minerals of this Table are soluble in water, and all possess a distinctly saline, bitter, or other taste. With the exception of *Rock Salt*, they occur, as a rule, in more or less earthy crusts, or in minutely crystalline efflorescences.

FIRST GROUP: *Giving chlorine reaction (i. e. azure coloration of flame) by fusion with phosphor-salt and copper oxide.*

Rock Salt (Na 39·31, Cl. 60·69).

Sylvine (K, Cl).

Sal Ammoniac (Am, Cl).

Rock Salt occurs chiefly in lamellar masses with strongly marked cubical cleavage, and occasionally in sub-fibrous examples and crystallized in cubes. Commonly colourless, but often shewing pale tints of brown, green, violet, &c., and sometimes deeply coloured, as bright red or brownish-purple. H 2; sp. gr. 2·1. BB, generally decrepitates, colours the flame strongly yellow, melts, and in prolonged heat sublimes. *Sylvine* (comparatively restricted in its occurrence) closely resembles *Rock Salt*, but colours the blowpipe-flame, or Bunsen-flame, violet. *Sal Ammoniac* occurs in colourless greyish or brownish crusts, or at times in trapezohedrons and other related forms (usually much distorted), on lava and other volcanic rocks. Also in small quantities in many coal-pits. BB, volatilizes without fusing, the evolved fumes giving out a strong ammoniacal odour.

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* See synopsis of their leading crystal types in the Mineral Tables attached to the author's "Blowpipe Practice," pages 253 to 255.

⁂ See also the carbonates of Group 4, below, these being often mixed with sodium chloride.

SECOND GROUP :—*Colouring the blowpipe-flame* (or *Bunsen-flame*) *distinctly green, if moistened with a drop of sulphuric acid or glycerine.*

Sassoline (Boracic Acid, B^2O^3, H^2O).

Borax or *Tinkal* (Na^2O, B^2O^3, H^2O).

Sassoline colours the flame green, *per se.* It occurs in small pearly scales, normally white, but often brownish, &c., from presence of ferruginous matter. Fuses with intumescence into a hard clear glass. *Borax* in its crude state (*Tinkal*) occurs in small Clino-Rhombic crystals and granular masses of a grey or brownish-white colour. BB, colours the flame intensely yellow, and melts with strong intumescence. Moistened with sulphuric acid, or simply with glycerine, it imparts a yellowish-green colour to the flame-border.

HIRD GROUP :—*Deflagrating when ignited on charcoal.*

(K^2O, N^2O^5).

Soda Nitre (Na^2O, N^2O^5).

Nitrocalcite (CaO, N^2O^5, H^2O).

Nitromagnesite (MgO, N^2O^5, H^2O).

These compounds evolve orange-red or brownish nitrous fumes when warmed, in powder, with a few drops of sulphuric acid. The two first are anhydrous. H 1·5 to 2. *Nitre* or *Saltpetre* crystallizes in long prism-pyramids of the Rhombic System, and imparts a violet colour to the flame-border. Commonly found in white or brownish incrustations. *Soda Nitre*, also known as *Nitratine* and *Chili-Saltpetre*, crystallizes in small, obtuse rhombohedrons, but occurs generally in crystalline granular examples of a white or greyish tint. It colours the flame-border intensely yellow.

Whilst *Nitre* and *Soda Nitre* dissolve entirely by fusion with carb. soda, *Nitrocalcite* and *Nitromagnesite* leave in that reagent an undissolved earthy mass. These latter substances also yield 10 or 11 per cent. water on ignition. Both occur in greyish-white crusts and efflorescences on the walls of limestone caverns, cellars, &c. The white crust left after ignition on charcoal, assumes a pink tinge in the case of *Nitromagnesite* after treatment with cobalt solution.

FOURTH GROUP : *Effervescing vigorously with dilute acid.*

Natron (Na^2O, CO^2, H^2O).

Trona (Na^2O, CO^2, H^2O).

Gaylussite (Na^2O, CaO, CO^2, H^2O).

Natron and *Trona*, are entirely absorbed by fusion on charcoal; *Gaylussite* (which is only partially soluble in water) leaves on the charcoal an earthy crust. They occur mostly in efflorescent coatings and small crystalline-granular masses of a white or greyish colour, more rarely in distinct crystals of the Clino-Rhombic System. *Natron* gives 63 per cent. water on ignition; *Trona*, 22 per cent.; and *Gaylussite*, 30 to 3[illegible] per cent. They are frequently mixed with sodium chloride.

FIFTH GROUP: *Forming BB with carb. soda on charcoal, in a reducing flame, an alkaline sulphide, which imparts when moistened a dark stain to lead test-paper or to a silver coin.**

Anhydrous sub-group:

Mascagnine (Amm. SO^3).
Glaserite (K^2O, SO^3).
Thenardite (Na^2O, SO^3).
Glauberite (Na^2O, CaO, SO^3).

Hydrated sub-group:

Mirabilite (*Glauber's Salt*: Na^2O, SO^3, H^2O 56 p.c.)
Epsomite (MgO, SO_3, H_2O 51 p.c.)
Green Vitriol or *Melantherite* (FeO, SO^3, H^2O 45 p.c.)

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* As a rule, the trial must be made by a lamp or candle-flame, as gas frequently contains sulphur, and this becomes communicated to the test matter. Lead test-paper is made by steeping some filtering or white blotting paper in a solution of acetate of lead, and drying for use.

Botryogene (MgO, FeO, Fe^2O^3, SO^3, H^2O 29 p.c.)

Blue Vitriol or *Chalcanthite* (CuO, SO^3, H^2O 36 p.c.)

Alum (K^2O [often replaced by Na^2O, MgO, MnO, FeO, &c.,] Al^2O^3, SO^3, H^2O 45·5 p.c.)

Alunogene (Al^2O^3, SO^3, H^2O 48 p.c.)

Mascagnine, *Glaserite*, *Thenardite*, and *Glauberite*, do not yield water when ignited in a test-tube. The three first dissolve entirely or leave no residue when fused with carb. soda. *Mascagnine* volatilizes with strong ammoniacal odour. It occurs in white or yellowish crusts or mammillated masses on certain lavas. *Glaserite* and *Thenardite* occur also in crusts and earthy coatings of a white or greyish colour. The first colours the flame violet; the second, yellow. Both melt readily, and are absorbed on charcoal, but sometimes decrepitate on first application of the flame. *Glauberite* is only partially soluble in water, but has like the other alkaline sulphates a bitter, saltish taste. Occurs in white, grey, reddish and other coloured crusts, and in small, Clino-Rhombic crystals. In carb. soda it is only in part dissolved; and on charcoal it leaves a white earthy mass unabsorbed. Chiefly found in association with rock-salt.

The sulphates of the second sub-group yield water on ignition in a test-tube or bulb-tube. *Mirabilite* (Glauber's Salt) dissolves entirely by fusion with carb. soda. *Per se* it colours the flame intensely yellow, and on charcoal is absorbed. Occurs mostly in efflorescent crusts on old walls, &c. Water-percentage 56. The other species belonging to this sub-group, occur equally in earthy crusts and coatings, or in some cases in efflorescences of minute hair-like crystals on aluminous shales, coals, iron and copper ores, &c. Ignited with cobalt solution, *Epsomite* is coloured pale-red; *Goslarite*, bright-green; and ordinary *Alum* and *Alunogene* bright-blue. The last occurs mostly in minute capillary crystals as an efflorescence on coal shales; and, although normally colourless, is frequently greenish or brownish from presence of Fe^2O^3. It passes into *Halotrichite* or *Feather Alum*. *Green Vitriol* and *Botryogene* leave BB a magnetic slag, and their solution gives a deep blue precipitate with ferricyanide of potassium. *Green Vitriol* is usually pale-green in color; *Botryogene* is red or brownish-yellow, with yellow streak; and it is only in part soluble in water. *Blue Vitriol* occurs in blue or greenish-blue coatings, and occasionally in crystalline examples, on copper ores. Moistened and rubbed on a knife blade, it coats the blade with a film of metallic copper.

⁂ See *Polyhallite* (Table XVIII.), which is partially soluble and has a slightly bitter but very feeble taste. Chiefly in pale-red, grey, and yellowish, columnar and fibrous masses. Ignition loss = 6 per cent.

NOTE:—Many other soluble or partially soluble sulphates of natural occurrence have been recognized, but most of these are comparatively rare, and many are indistinctly characterized. See the author's "Blowpipe Practice," pages 153 to 158.

TABLE XIV.

(Lustre non-metallic. Hardness insufficient to scratch glass. Combustible.

The minerals of this Table when held in the form of a thin fragment against the flame of a Bunsen burner or common candle immediately take fire, and continue to burn for a short time after removal from the flame. The test fragment should be taken up by a pair of steel forceps (without platinum tips) and held just within or against the flame-border.

FIRST GROUP:—*Emitting a garlic-odour during combustion.*

Realgar (As 70, S 30).

Orpiment (As 61, S 39).

Realgar has a red colour and orange-yellow streak, and is commonly in small granular masses or Clino-Rhombic crystals, the latter as a rule more or less indistinct. *Orpiment* is golden-yellow with pearly and sub-resinous lustre, and light-yellow streak; and it occurs in foliated, scaly, and granular masses; more rarely in small prismatic crystals of the Rhombic system. H, in both, 1·5 to 2. Both species melt very easily, and volatilize in dense fumes.

SECOND GROUP:—*Emitting a sulphurous odour during combustion.*

Native Sulphur.

Cinnabar (Hg~~S~~ 86·2, S 13·8).

Native Sulphur is yellow or reddish, with pale-yellow streak and resinous lustre. It is commonly in granular masses and occasionally in small crystals—mostly acute rhombic pyramids. Its sp. gr. does not exceed 2·1 and is generally 1·9 or 2. It melts into red-brown drops which become pale yellow on cooling, and readily volatilizes. *Cinnabar* is commonly red in colour, but is sometimes reddish lead-grey, and occasionally almost black from admixture of bituminous matters. The streak is always red, and the sp. gr. usually about 8, although somewhat lower in impure carbonaceous varieties (6·7 to 7·5). BB, it rapidly volatilizes. By ignition with dry carb. soda, iron filings, or other reducing agents in a small flask or bulb-tube, it yields a grey sublimate, which runs into fluid globules when rubbed by an iron wire or thin glass rod.

THIRD GROUP: *Emitting during combustion a bituminous or aromatic odour.*

Bituminous Coal (H, C, O).
Brown Coal or *Lignite* (H, C, O).
Asphalt or *Bitumen* (H, C, O)
Amber (H, C, O).

Bituminous Coal, *Brown Coal*, and *Asphalt*, burn with yellow, smoky flame and bituminous odour. *Bituminous* or *ordinary coal* is more or less distinctly laminated in structure, with alternate thick layers of solid, lustrous coal, and thin layers of soft black carbonaceous matter—known as "mineral charcoal"—in which a distinctly woody structure is observable. Streak black; sp. gr. 1·2 to 1·5. Scarcely or not at all attacked by boiling in solution of caustic potash. *Brown Coal* in typical examples has a more or less distinctly ligneous appearance, with brown colour and brown streak ; but many examples are laminated, and comparatively dense and dark in colour, and thus pass into ordinary coal, from which they differ chiefly by occurring at a higher geological horizon. As a rule, however, they are less dense; and they yield a lighter coke, which never presents the fused agglutinated character of the coke yielded by most examples of ordinary coal. They generally contain, also, more water, and frequently a larger amount of "ash," or mineral matter. True brown-coals or lignites impart a brown colour to a boiling solution of caustic potash. Cannel coals and Jet are intermediate varieties. *Asphalt* or *Bitumen* occurs in solid, viscous, and liquid examples, the latter passing into *Petroleum.* The solid varieties show a conchoidal fracture. *Elaterite* is a soft, spongy variety, resembling caoutchouc. *Albertite,* a black, brittle, compact, highly lustrous and inflammable substance, is closely related.

Amber occurs in nodular masses of a deep or pale-yellow colour passing into yellowish-brown. H 2 to 2·5 ; sp. gr. 1·0 to 1·1. Strongly electric by friction. Burns with yellow flame and aromatic odour.

⁂ Various so-called "mineral resins" (*Ozokerite, Hartite, Hatchettine, Scheererite, &c.*) belong also to this group, but are comparatively rare and of little interest as minerals. They occur mostly in soft wax-like masses of a yellow or brownish colour, or in white pearly laminæ. See the author's "BLOWPIPE PRACTICE," pages 132 and 133. Also pages 76 to 81, of the same work, for a method of assaying coals by the blowpipe.

TABLE XV.

[Lustre non-metallic. Hardness insufficient to scratch glass. Effervescing in dilute acid].

The minerals of this Table consist entirely of carbonates. The effervescence is most readily produced by inserting some of the substance (in a coarsely powdered state) into a test-tube, and then covering it with hydrochloric acid diluted with about an equal volume of water. If the effervescence be feeble, the acid must be gently warmed over a spirit-lamp or Bunsen-burner. Fused with borax or phosphor-salt, a vigorous effervescence is also produced, from the escape of CO^2.

First Group :—*Entirely soluble BB in carb. soda. Per se, colouring the flame green or red.*

The test may be made by fusion with carb. soda on platinum wire or on charcoal. In the latter case, the whole of the test-matter is absorbed ; but the complete solution of the substance is perhaps better seen in a loop of platinum wire, before the fused bead solidifies. If any lime be present in the bead, it remains undissolved.

Witherite (BaO, CO^2).

Strontianite (~~Ba~~O, CO^2).

With *Witherite*, the point and border of the blowpipe-flame is coloured apple-green; with *Strontianite*, carmine-red —the coloration coming out most vividly after prolonged ignition of the test-fragment. *Witherite* fuses readily into a clear glass which becomes opaque on cooling: if it contain

MnO, the glass is pale blueish-green. *Strontianite* forms BB a cauliflower-like mass, the separate ends of which fuse upon the edges. Both species occur in crystals of the Rhombic System, but more commonly in fibrous, columnar, granular, and other uncrystallized examples. In *Witherite*, the sp. gr. equals 4·2 to 4·4; in *Strontianite*, 3·6 to 3·8.

⁂ *Alstonite* (= *Bromlite*) and *Baryto-calcite*, are compounds of BaO, CO^2, and CaO, CO^2. They colour the blowpipe-flame pale-green, but are only partially soluble by fusion in carb. soda. Average sp. gr. 3·7. Some examples of *Strontianite*, also contain a small per centage of CaO.

SECOND GROUP: *Yielding, BB, on charcoal, metallic globules (Copper or Lead).*

Malachite (CuO, CO^2, H^2O).

Azurite (CuO, CO^2, H^2O).

Cerussite (PbO, CO^2).

These minerals are easily reduced *per se*, but the reduction is rendered still more easy by mixing the test-matter, in powder, with some carb. soda.

Malachite and *Azurite* are copper carbonates—green and blue, respectively, in colour. Both yield water on ignition. The hydrochloric acid solution is rendered deep blue by ammonia, used in sufficient quantity. *Malachite* is commonly in botryoidal and fibrous masses, and is often zoned in deep and light-green tints. *Azurite* is chiefly in groups of rich blue (Clino-Rhombic) crystals. Both occur also in earthy coatings or "blooms" on copper ores and copper-holding rocks.

Cerussite is a lead carbonate, either colourless, or greyish, &c., and sometimes nearly black from incipient conversion into PbS. It presents a peculiar vitreo-adamantine lustre, and occurs in massive and crystallized examples. The crystals belong to the Rhombic System, and are frequently in cruciform and stellate groups. Sp. gr. 6·5. Exceedingly brittle.

Third Group: *Becoming magnetic after ignition, or forming a turquoise-enamel by fusion with carb soda.*

Siderite or *Spathic Iron* (FeO, CO^2 but part of the FeO often replaced by MnO, &c.)

Ankerite (CaO, MgO, MnO, FeO, CO^2).

Rhodochrosite or *Manganese Spar* (MnO, CO^2).

These carbonates are placed together because, from the vicarious relations of the monoxides FeO, MnO, MgO, CaO, &c., they often give similar reactions. Examples of *Siderite* and *Ankerite* thus frequently give a strong reaction of manganese, and some examples of *Rhodochrosite* (= *Diallogite*) become magnetic after ignition.

Siderite or *Spathic Iron Ore* occurs under various conditions, chiefly in groups of nearly colourless, yellow, and yellowish-brown rhombohedrons (often with curved faces) in many mineral veins; in fibro-botryoidal masses and small spherical concretions of a dark-green or brownish colour (= *Spherosiderite*) in basaltic rocks; in pisolitic examples in various Mesozoic formations; and in nodular masses and layers (often very impure, or mixed with earthy and carboniferous matter, and partially changed into brown iron ore) in coal strata generally. The latter variety, known as clay iron ore, &c., yields a large part of the iron of commerce. The nodules when split open generally shew the impression of a fern frond or other organic body. Sp. gr. of *Siderite* generally, 3·7 to 4·1. *Ankerite* is connected with *Siderite* by many intervening varieties, and can scarcely be distinguished from the latter except by its lower sp. gr. (= 2·9 to 3·3) and by the interfacial angles of its rhombohedral crystals. (The angle over a polar edge in *normal Siderite* equals 107° ; in *Ankerite*, 106° 12'). The presence of a large amount of lime in *Ankerite* is also more or less characteristic.* Both species blacken on ignition and become magnetic.

Rhodochrosite, also known as *Diallogite* and *Manganese Spar*, is connected with *Siderite* by varieties of passage, more especially by the variety of the latter known as *Oligon Spar*. Typically, *Rhodochrosite* is of a pale-red or rose-pink colour, and is commonly found in botryoidal and lamellar masses, more rarely in small rhombohedrons. It weathers brown. Blackens on ignition, and forms with carb. soda BB a green-blue turquoise enamel. Sp. gr. 3·3 to 3·6.

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* The presence of lime is easily determined as follows: Dissolve the test-substance in hydrocloric acid; add a few drops of nitric acid, and boil (to convert FeO into Fe^2O^3); then dilute, and add ammonia: this precipitates the Fe^2O^3. Filter, add a little more ammonia to the filtrate, and then some amm. oxalate; this throws down the lime. Finally, to determine magnesia, filter from the lime precipitate, and test with sodium phosphate. Care must of course be taken to see in each case that the precipitation is complete. Lime is also easily detected by a small spectroscope. See BLOWPIPE PRACTICE, p. 55.

FOURTH GROUP: *Assuming a light-green colour after ignition with cobalt solution.*

Smithsonite or *Zinc Spar* (ZnO, CO^2)

This mineral is the only representative of the present group. It occurs chiefly in botryoidal and incrusting masses, and in aggregations of small rhombohedrons, either colourless and vitreous, or yellowish-grey, brownish, &c., and opaque. It readily scratches other carbonates and even fluor spar. H = 5; sp. gr. 4 to 4·4. Yields BB with a mixture of carb. soda and borax, a sublimate of ZnO—lemon-yellow whilst hot and white when cold, and becoming light-green after ignition with cobalt nitrate. The saturated borax bead becomes opaque on cooling or when flamed.

FIFTH GROUP: *Shewing alkaline reaction after ignition, but not giving reactions of preceding groups.*

A small fragment must be strongly ignited on charcoal or in the platinum-tipped forceps; placed when cool on a slip of red litmus-paper; and moistened with a drop of distilled water: a blue spot will appear beneath and around the test-matter. The saturated borax bead becomes opaque on cooling or by flaming—*i. e.*, by subjection to an intermittent flame.

Calcite ($CaO\ 56, CO^2\ 44$).

Dolomite (CaO, MgO, CO^2).

Magnesite (MgO, CO^2).

Arragonite (CaO, CO^2).

Calcite, Dolomite, and *Magnesite*, are rhombohedral carbonates, closely related to *Ankerite, Siderite*, and *Rhodochrosite*, and frequently passing into these by intermediate varieties (*Breunerite, Rœperite*, &c.) *Calcite* occurs especially in rhombohedrons and scalenohedrons, obtuse and acute, in combinations of six-sided prism and rhombohedron (nail-headed spar, &c.), in cleavable lamellar examples, and in numerous massive or rock varieties of granular, oolitic, and other texture. BB, infusible, but glows strongly, and after prolonged ignition imparts a distinct red tinge to the flame-border. Cleavage rhombohedral (with angle of 105° 5' over polar edges) strongly pronounced. Sp. gr. 2·6 to 2·8. Commonly white or colourless, but also variously tinted. Transparent rhombohedrons (= Iceland spar, &c.) shew double refraction in a marked degree when placed across a thin line in the direction of their longer diameter. *Dolomite* closely resembles *Calcite* (but with angle of 106° 15' over polar edge of its common and cleavage rhombohedron) and like the latter it occurs crystallized, massive, &c., and in rock varieties. Dissolves feebly, as a rule, in cold acid, but briskly when the acid is warmed. Frequently brown (whence "brown spar") from some of its MgO being replaced by FeO.* Sp. gr. 2·8 to 3. *Magnessite* is less common than the preceding, but closely resembles *Dolomite* in effervescing somewhat feebly in cold acids. The rhombohedral angle equals 107° 16' to 107° 29'. It occurs commonly, however, in massive examples. Sp. gr. 2·8 to 3·1. White, yellowish, grey, &c., in colour. The powder (in pure examples) becomes distinctly reddened after ignition with cobalt solution.

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* For the detection of CaO, MgO, and FeO (if present) see the preceding footnote, page 73.

Arragonite has the same composition as *Calcite*, but crystallizes in Rhombic forms (often in twins of marked pseudo-hexagonal aspect), and differs also slightly by its greater hardness (3·5 to 4 in place of 3), and by its somewhat higher sp. gr. (2·7 to 3). Occurs frequently crystallized, and also in fibrous and coralloidal examples of a white, pale-yellow, brownish-violet, and other colour. Infusible, but generally falls into powder on ignition. Effervesces strongly in cold acids.

⁂ See also *Baryto-Calcite* and *Alstonite*, infusible carbonates, colouring the flame pale-green, and possessing an average sp. gr. of 3·7.

TABLE XVI.

[Lustre non-metallic. Hardness insufficient to scratch glass. Yielding BB on charcoal a garlic-like odour.]

Group 1: *Yieding BB on charcoal a silver globule. Colour and streak, deep-red.*

Proustite or *Light-Red Silver Ore* (Ag 66, As 15, S 19).

This mineral has a strong, adamantine lustre, and is commonly more or less transparent. H 2·5; sp. gr. 5·4 to 5·6. Fusible per *se*, if held at the side of a Bunsen or candle-flame, without the aid of the blowpipe. The reduced globule, as obtained BB on charcoal, retains its bright surface in an oxidating flame. As an additional proof that it consists of silver, it may be fused with a piece of pure lead, and then cupelled.

GROUP 2. *Yielding BB on charcoal a globule of reduced lead:*

Mimetesite ($PbO, As^2O^5, PbCl^2$).

This mineral is isomorphous with *Pyromorphite*, the chloro-phosphate of lead. Generally yellow, orange, or brown; more rarely grey or colourless. Mostly in globular or barrel-shaped crystals of high sp. gr. (7 to 7·3). This latter character is especially distinctive. Fused in the forceps, the lead crystallizes over the surface on cooling, but on charcoal it becomes reduced, a yellow ring-deposit forming also on the support. With phosphor-salt and copper oxide, it produces an azure-blue, copper-chloride flame.

GROUP 3. *Yielding BB on charcoal a magnetic slag or bead.*

Pharmacosiderite or Cube Ore (Fe^2O^3, As^2O^5, H^2O).

Scorodite (Fe^2O^3, As^2O^5, H^2O).

These ferruginous arseniates yield a considerable amount of water on ignition in the bulb-tube. The first nearly 17, and the second nearly 16 per cent. *Pharmacosiderite* occurs essentially in very small cubes with a triangular plane on each alternate angle (= cube and tetrahedron), dark-green or yellowish-brown in colour, and mostly in drusy aggregations. *Scorodite* occurs in fibrous examples, or in groups of thin pyramidal or prismatic crystals, of a dark-green or blackish-blue colour, passing into reddish-brown.

Group 4. *Producing when moistened with hydrochloric acid an azure-blue (copper-chloride) flame. Giving also, after roasting, strong copper reactions with borax. Colour, green or blue.*

Olivenite (CuO, As^2O^5, H^2O).
Erinite (Cuo, As^2O^5, H^2O).
Clinoclase (CuO, As^2O^5, H^2O).
uchroite (CuO, As^2O^5, H^2O).
Tirolite (CuO, As^3O^5, H^2O ; CuO, CO_2).
Chalcophyllite (CuO, As^2O^5 A^2O).
Liroconite (CuO, As^2O^5, H^2O ; Al^2O^3, P^2O^5) ?

These hydrated copper-arseniates may be separated (as regards determination) into two sub-groups. In the first, comprising *Olivenite*, *Erinite*, and *Clinoclase* (Strahlerz), the amount of water yielded on ignition is considerably under 10 per cent.—viz., a little over 3 per cent. in *Olivenite*, 5½ per cent. in *Erinite*, and just 7 per cent. in *Clinoclase*. In the second sub-group the water averages about 20 per cent., varying in the different species from 18·70 (*Euchroite*) to from 20 to 25 per cent. (*Tirolite, Chalcophyllite, Liroconite*). Without determining, therefore, the actual percentage of water, the operator will readily see, by the small or large amount of moisture deposited in the tube, to which sub-group the test-mineral belongs. When ignited on charcoal, most of these arseniates deflagrate ; and all yield by quick fusion a light or dark grey, brittle, arsenical globule, which commonly shews a radiated or crystallized surface on congealing. They are also readily attacked (in fine powder) and entirely or in great part dissolved, by strong ammonia, forming a deep blue solution. *Tirolite*, however, leaves a residuum of CaO, CO^2; and white flecks of Al^2O separate from *Liroconite*, Apart from these distinctions, the separate species are not always of easy determination without complete analysis, but the following is a comparative summary of their more salient characters :

Olivenite and *Clinoclase* are dark-green, often blackish-green ; the first, Rhombic ; the second, Clino-Rhombic, in crystallization ; but whilst *Olivenite* is commonly in small crystals (resembling in general shape those of the common basaltic augites), *Clinoclase* is most frequently in radio-fibrous examples, whence its German name of "Strahlerz."

Erinite, *Euchroite*, and *Chalcophyllite*, are mostly of a bright, emerald-green colour. The latter occurs essentially in tabular, micaceous examples (whence its popular name of "copper mica"), and it is thus easily recognized. *Erinite* is chiefly in small rounded masses of concentric-scaly structure, and is harder than other cupreous arseniates, being equal in hardness to fluor-spar, or even slightly harder than that mineral. *Euchroite* is commonly in small, thick, vertically-striated crystals of the Rhombic System.

Tirolite and *Liroconite* are light-green or light-blue in colour. The first occurs mostly in mamillary radio-fibrous examples, and it effervesces in acids from the presence of CaO, CO^2. *Liroconite* is essentially in small prismatic crystals. See also the action of ammonia on these arseniates, as described above.

GROUP 5—*Yielding a rich-blue glass by fusion with borax. Colour rose-red or light-green.*

Erythrine or *Cobalt Bloom* (CoO, As^2O^5, H^2O).

Roselite (CoO, CaO, MgO, As^2O^5, H^2O).

Annabergite or *Nickelgreen* (NiO, CoO, As^2O^5, H^2O).

Erythrine and *Roselite* are of a rose or peach-blossom red colour. *Annabergite* is apple-green. The two first become blue on ignition in a narrow test-tube or bulb-tube,—*Erythrine* yielding 24 per cent., and *Roselite* 8·20 per cent. water. The first occurs chiefly in thin, prismatic crystals (easily cleavable in one direction) and in flat-fibrous or bladed examples. *Roselite* is principally in rounded aggregations of small, indistinct crystals. Both occur also in earthy efflorescences.

Annabergite, distinguished from the above by its light-green colour, is essentially a nickel arseniate, but almost invariably contains a small amount of cobalt arseniate, and thus gives a blue glass by fusion with borax. It occurs mostly in acicular crystals and efflorescent coatings on nickel ores. Forms a green solution in hydrochloric acid, which becomes blue on addition of ammonia in excess.

GROUP 6—*Colour essentially white.*

Pharmacolite (CaO, As^2O^5, H^2O).

This is the only mineral of general occurrence belonging to the present group. It occurs chiefly in acicular, fibrous, and efflorescent examples; sometimes in small pearly crystals of the Clino-Rhombic System. Easily fusible. Yields about 24 per cent. water on ignition.

TABLE XVII.

[Fusible or reducible on charcoal. Streak-powder, coloured.]

FIRST GROUP: *Partly or wholly volatilizable with emission of antimonial fumes. Streak, red.*

Pyrargyrite or *Dark-Red Silver Ore* (Ag, Sb, S).

Kermesite (Sb^2S^3, Sb^2O^3).

These minerals exhibit in most examples a sub-metallic lustre. Both melt without the aid of the blowpipe if held in the form of a small fragment against the edge of a candle or Bunsen flame. On charcoal, they give a dense-white antimonial sublimate or ring-deposit: *Kermesite* volatilizing entirely, and *Pyrargyrite* yielding a large globule of silver. *Kermesite* occurs in groups of acicular crystals or in small radio-fibrous tufts, mostly accompanying *Antimony Glance. Pyrargyrite* is chiefly in cleavable masses, and in Hexagonal or Rhombohedral crystals, of a dark blueish-red colour passing into dark lead-grey. Sp. gr. 5·7 to 5·9. It often emits an arsenical odour on ignition, from the presence of As^2S^3, the latter partly replacing Sb^2S^3.

See also, *Cinnabar* (Table XIV).

SECOND GROUP: *Non-volatile on ignition. Colour, dark or bright red, with red or orange streak.*

Cuprite or *Red Copper Ore* (Cu^2O).

Crocoisite or *Lead Chromate* (PbO, CrO^3).

Cuprite is dark-red or blueish-red in colour, with red streak, but the colour is often obscured by a coating of green carbonate. It occurs in cleavable masses, and very commonly in small octahedrons and rhombic dodecahedrons. Sp. gr. 5·7 to 6. Easily reduced BB to metallic copper, colouring the flame deep-green.

Crocoisite has a bright-red colour and orange-yellow streak. It occurs in groups of more or less acicular Clino-Rhombic) crystals, and in small flaky masses and coatings. Sp. gr. 5·9 to 6. BB, decrepitates, blackens, and becomes reduced to metallic lead. With borax, forms an emerald-green glass. With hydrochloric acid, causes the evolution of chlorine fumes.

⁂ See also *Phœnicite* (a lead chromate with red streak, often in fibrous masses accompanying *Crocoisite*); and *Minium* or *Red oxide of lead* (mostly in earthy crusts with orange-yellow streak). Both cause the evolution of chlorine when warmed with hydrochloric acid, and both are easily reducible BB on charcoal; but *Minium* gives no green glass by fusion with borax or phosphor-salt.

⁂ See also (Table XIX) *Red Iron Ore* and *Brown Iron Ore*, which fuse on thin edges in a reducing flame, and become magnetic.

THIRD GROUP: *Colour and streak, black or brownish-black, giving BB, strong copper-reactions.*

Melaconite (CuO).

This is the only mineral of ordinary occurrence, referable to the present group. It occurs in more or less earthy masses, and in pseudomorphs after *Cuprite*. On charcoal, easily reduced to metallic copper. The name *Tenorite* is bestowed upon the same compound from Vesuvius, but this presents a distinctly metallic or sub-metallic aspect. It occurs in small hexagonal plates and scales of an iron-black or steel-grey colour.

FOURTH GROUP: *Colour green, paler in the streak. Yielding water on ignition, and giving BB, with carb. soda on charcoal, a copper globule.*

Atacamite ($CuCl^2$, CuO, H^2O).

Brochantite (CuO, SO^3, H_2O 12 to 15 %).

Libethenite (CuO, P^2O^5, H^2O 4 %).

Phosphorchalcite (CuO, P^2O^5, H^2O 8 %).

Ehlite (CuO, P^2O^5, H^2O 9 %).

Tagilite (CuO, P^2O^5, H^2O 10·5 %).

Chalcolite or *Copper-Uranite* (CuO, U^2O^3, P^2O^5, H^2O 15 to 16 %).

Atacamite is a cupreous oxy-chloride, and, as such, it colours the blowpipe-flame bright azure-blue. Occurs in small rhombic crystals, and in grains, of a rich green colour. *Atlacite* is this substance partly converted into carbonate.

Brochantite is a copper sulphate, and thus forms by fusion with carb. soda on charcoal an alkaline sulphide, which produces a dark-brown or black stain when moistened and laid on a silver coin.* All the other minerals of the group are phosphates. Their nitric-acid solution when warmed with a few particles of amm. molybdate gives a canary-yellow precipitate. *Libethenite* is dark olive-green or blackish-green, and occurs commonly in groups of small rhombic crystals, isomorphous with the cupreous arseniate *Olivenite*. Its ignition loss does not exceed 4 per cent. *Phosphorchalcite, Ehlite* and *Tagilite* are of an emerald-green or clear-green colour. They occur mostly in groups of very small and more or less indistinct crystals (Rhombic or Clino-Rhombic), and in radio-fibrous, mammillated, and earthy examples. *Ehlite* is especially distinguished by its easy cleavage in one direction, and its more or less bladed structure. *Chalcolite*, the copper-uranium phosphate, is also easily cleavable in one direction, and it presents a rich emerald-green colour, with pearly lustre on the cleavage plane. As a rule, it is readily distinguished from the copper phosphates proper, by the square, tabular crystals and broad leafy masses in which it commonly occurs; as well as by its high ignition-loss, amounting to over 15 per cent.

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* The trial should be made with an oil or candle flame, as coal-gas often contains sulphur, and imparts this to the test-matter when the fusion is effected by a modified Bunsen-burner.

FIFTH GROUP: *Colour yellow or yellowish-green, with pale-yellow streak. Yielding water on ignition.*

Uranite or *Autunite* (CaO, U^2O^3, H^2O 15 to 19 %).

This is the only mineral of ordinary occurrence referable to the present group. It occurs in small tabular crystals (of Tetragonal aspect), and in leafy masses, very easily cleavable in one direction—the cleavage-plane shewing a pearly lustre, as in the copper-uranium phosphate, *Chalcolite*. Easily fusible into a dark bead. Forms with phosphor-salt, BB, a yellowish-green glass in the O. F., and a bright chrome-green glass in the R. F.

SIXTH GROUP: *Colour indigo-blue or blueish-green. Fusible on charcoal into a magnetic globule.*

Vivianite (FeO, Fe^2O^3, P^2O^5, H^2O 28 %).

The above is the only mineral of common occurrence belonging to this group. (For related iron phosphates, mostly yellow or brown in colour, see the author's BLOWPIPE PRACTICE, page 165.)

Vivianite is normally colourless, but always presents a blue or greenish-blue colour by the FeO becoming rapidly changed in part into sesquioxide. The streak is nearly colourless, but quickly becomes pale-blue. Examples are commonly in fibrous and bladed masses, with marked cleavage, shewing pearly lustre, in one direction. Earthy examples are also common, and groups of small clino-rhombic crystals occur at some localities. In the bulb-tube it swells up, reddens, and yields a large amount of water. Fuses BB into a magnetic globule.

⁂ See, also, *Chlorite* (Table XVIII.), which fuses on the edges, in some examples, into a dark, magnetic slag. Commonly in dark-green, soft, foliated, scaly, or scaly-compact masses, with in some cases a distinctly greenish streak.

TABLE XVIII.

[Reducible or more or less distinctly fusible. Streak, uncoloured.]

FIRST GROUP: *Reducible and volatilizable on charcoal, with deposition of a dense white coating on the support.*

Valentinite (Sb^2O^3).

Senarmontite (Sb^2O^3).

Cervantite (Sb^2O^3, Sb^2O^5).

Antimony Ochre (Sb^2O^3, H^2O).

Stiblite (Sb^2O^3, Sb^2O^5, H^2O).

The minerals of this group are comparatively unimportant. They occur mostly as white or yellowish incrustations on

Antimony Glance and other antimonial sulphides. *Valentinite,* which contains 83½ per cent. antimony, occurs also in acicular or small tabular crystals of the Rhombic System; sp. gr. 5·3 to 5·6. BB, becomes yellow, melts very easily, and volatilizes. *Senarmontite* has the same composition and general aspect, but crystallizes in regular octahedrons, mostly with curved faces. Both sublime readily by ignition in the bulb-tube.

Cervantite is a combination of antimonious and antimonic acids, and although reducible (and then volatilizable) on charcoal, especially if mixed with carb. soda, it does not fuse *per se,* and is not volatilized in the bulb-tube. Yellow, yellowish-white; sp. gr. 4.

Antimony Ochre and *Stiblite* much resemble the above, but yield water on ignition. Occur essentially in earthy incrusting examples of a yellow or yellowish-white colour, and occasionally in pseudomorphous crystals derived from *Antimony Glance.* *Antimony Ochre* fuses easily; *Stiblite* is infusible, but becomes reduced on charcoal.

SECOND GROUP: *Yielding per se or with carb. soda on charcoal, metallic globules, and depositing (Kerargyrite excepted) a yellow coating on the support.*

Kerargyrite ($AgCl$).

Pyromorphite ($PbO, P^2O^5, PbCl^2$).

Anglesite (PbO, SO^3).

Wulfenite (PbO, MO^3).

Stolzite (PbO, WO^3).

Eulytine (Bi^2O^3, SiO^2).

Kerargyrite and *Pyromorphite* produce a strongly-marked chlorine reaction, *i. e.*, an azure-blue coloration of the flame-point, when fused with phosphor-salt and copper oxide ; or with phosphor-salt, alone, in a loop of copper wire. *Kerargyrite*, commonly known as "Horn Silver Ore," is easily distinguished by the large globule of silver which it yields BB on charcoal. It occurs commonly in waxy-looking, very sectile examples of a violet-brown, grey or greenish colour. H 1 to 1·5 ; sp. gr. 5·6. Sometimes mixed with AgBr and AgI, when the flame-point is coloured more or less green. *Pyromorphite* occurs chiefly in hexagonal prisms (sometimes acicular and often barrel-shaped) and in mammillated and granular examples of a dark-green, light-green, brown, grey, or yellow colour. H 3·5 to 4 ; sp. gr. 6·9 to 7. Fused on charcoal, *per se*, it forms a white or light-coloured globule which crystallizes with broad facets on cooling. With carb. soda, easily reduced to metallic lead.

Anglesite with carb. soda on charcoal gives strong sulphur-reaction—*i. e.*, the slag around the reduced lead produces a dark stain when placed with a drop of water on a silver coin* Commonly in colourless or greyish (Rhombic) crystals and crystalline masses of marked adamantine lustre, and in mammillated and other examples. Sp. gr. 6·1 to 6·4.

Wulfenite and *Stolzite* form deeply-coloured green or greenish-blue glasses by fusion in a reducing flame with phosphor-salt. *Wulfenite* is mostly in small, tabular crystals of the Tetragonal System, yellow or yellowish-grey in colour, or sometimes red from intermixture of lead chromate. Sp. gr. 6·7. As pointed out by von Kobell, a beautiful blue coloration ensues when the powdered mineral is warmed with concentrated sulphuric acid in a porcelain capsule, and some alcohol is added to the mixture. Stolzite is especially distinguished by its high specific gravity, 7·9 to 8·1, and by the fine blue or greenish-blue glass which it forms by fusion with phosphor-salt in a reducing flame. It occurs commonly in very small, often fusiform, square-based pyramids and other Tetragonal crystals, and also in mammillated examples, grey or brown (more rarely red or green) in colour. Nitric acid dissolves out the PbO, and leaves a yellow residuum of WO^3.

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* As stated in a preceding foot-note, the fusion should be effected by the flame of a candle or that of an oil lamp. There is always risk of sulphur being communicated to the test-matter by a gas flame.

Eulytine (sometimes known as "bismuth blende") occurs in very small tetrahedral crystals and botryoidal examples of a brown or yellowish colour. H 4·5 to 5 ; sp. gr. about 6. Fuses into a dull, brownish bead, and with carb. soda on charcoal yields reduced (more or less brittle) metal and a deep-yellow sublimate. As with bismuth compounds generally, when fused with a mixture of sulphur and potassium iodide, it deposits on the charcoal a sublimate of a vivid scarlet colour. Gelatinizes in hydrochloric acid.

THIRD GROUP: *Rapidly dissolved BB by phosphor-salt on platinum-wire. No water evolved on ignition in the bulb-tube.*

Scheelite (CaO, WO^3).
Fluor Spar (CaF^2).
Cryolite (Na, Al, F).
Barytine or *Heavy Spar* (BaO, SO^2).
Celestine (SrO, SO^3).
Anhydrite (CaC, SO^3).
Triphylline ($Li^2O, Na^2K^2O, MnO, FeO, P^2O^5$).

Scheelite fuses on the edges only, and therefore belongs properly to Table XX., where it will be found described. It is at once distinguished from the minerals of the present Table, also, by its high specific gravity (5·9 to 6·2).

Fluor Spar and *Cryolite*, warmed in powder with sulphuric acid, give off stifling fumes which corrode glass more or less strongly. The trial is best made in a platinum crucible covered with a piece of glass. On washing the glass, the corrosion is readily seen.

Fluor Spar, as a rule, is easily recognized by its common occurrence in cubes, which are either colourless, or more usually amethystine, deep blueish-green, pale-green, yellow, pale blueish-grey, or rose-red, in colour. It occurs also in columnar examples, mostly zoned in different tints, and occasionally in compact, hornstone-like masses. Sp. gr. 3·1 to 3·2. The crystals present a marked octahedral cleavage, and thus some of the angles of the cubes are frequently broken off. BB, generally decrepitates strongly, and melts into a white, opaque bead. After prolonged ignition, it tinges the flame-point distinctly red, and reacts alkaline—*i.e.*, imparts when moistened a blue colour to red litmus-paper. Gently heated in the dark, the powder exhibits a green or blueish phosphorescence.

Cryolite occurs in white, lamellar masses with nearly rectangular cleavage. Small fragments melt easily if held against the edge of a candle-flame. BB on charcoal, runs into liquid fusion and is in great part absorbed, leaving a white, earthy residuum which becomes bright-blue when moistened with cobalt nitrate and again ignited. H 2·5 to 3; sp. gr. 2·95. *Chiolite* and *Pachnolite* are closely related.

Barytine, *Celestine*, and *Anhydrite* are sulphates, and thus form by fusion with carb. soda on charcoal, a so-called "hepar" or reddish mass which imparts when moistened a dark stain to the surface of a silver coin or piece of lead test-paper; but the fusion should be made by the flame of a candle or oil-lamp, as ordinary gas frequently contains sulphur. Fused *per se* in the blowpipe forceps, *Barytine* colours the flame-point pale-green, and *Celestine* imparts to it a carmine-red colour, the colour becoming very intense on prolonged subjection of the test-fragment to the action of the flame. Both dissolve entirely BB, in carb. soda, whilst *Anhydrite* leaves undissolved a white earthy mass. The sp. gr. of *Barytine* equals 4·3 to 4·7; that of *Celestine*, 3·9 to 4; and that of *Anhydrite*, only 2·8 to 3. *Barytine* occurs in rhombic crystals (often tabular);* and in lamellar, fibrous, and other examples, either colourless, or opaque-white, yellow, pale-red, brown, &c., in colour. *Celestine* occurs also in colourless rhombic-crystals (often associated with native sulphur), and very commonly in fibrous and lamellar examples of a light or deep-blue color. *Anhydrite* is rarely in distinct crystals, but commonly in lamellar, granular, and other masses, mostly of an opaque-white or greyish colour, or variously tinted.

Triphylline occurs in cleavable, lamellar masses of a greyish-green or greyish-blue colour. H 4 to 5; sp. gr. 3·5 to 3·6. Easily fusible, generally colouring the flame both green and red. The latter colour comes out very strongly if test-matter be moistened with hydrochloric acid or fused with barium chloride. The solution in nitric acid gives a canary-yellow precipitate with amm. molybdate.

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* See synopsis of its crystal types in the Tables which accompany the author's *Blowpipe Practice*, page 160. See also, in the same work, the very distinctive spectroscopic reactions (as brought out by a Bunsen burner and small pocket-spectroscope) of *Barytine*, *Celestine*, *Anhydrite*, and related minerals.

FOURTH GROUP: *Characters like those of the preceding Group, but yielding water on ignition.*

Gypsum or Selenite (CaO, SO^3, H^2O).

Polyhallite ($K^2O, CaO, MgO, SO^3, H^2O$).

These minerals fused with carb. soda (and a little borax) on charcoal form an alcaline sulphide which imparts, when moistened, a dark stain to a silver coin or slip of lead test-paper. Ignited in a bulb-tube or test-tube, both yield water: *Gypsum* 21, and *Pollyhallite* 6 per cent. The latter is partly soluble in water, and has a feeble, bitter taste.

Gypsum occurs in clino-rhombic crystals and in lamellar, granular, and fibrous masses, either colourless, or of an opaque-white, pale-red, or other colour. The crystals shew a marked cleavage in one direction, with pearly lustre on the cleavage plane. All varieties yield to the finger-nail; and transparent specimens become immediately opaque in a candle-flame. BB, fuses into a white globule which reacts alkaline after prolonged ignition, and tinges the flame distinctly red. Sp. gr. 2·2 to 2·4. *Polyhallite* is mostly in flesh-red or greyish, fibrous and lamellar masses. Sp. gr. 2·7 to 2·8; H 3 to 3·5. Easily fusible into an alkaline, hollow bead.

FIFTH GROUP: *Slowly and only partially decomposed by fusion with phosphor-salt, a silica-skeleton remaining in* *the fused bead. No water (or merely traces) evolved by ignition in the bulb-tube.*

Asbestus (CaO, MgO, SiO^2).

Krokidolite (Na^2O, H^2O, MgO, FeO, SiO^2).

Lepidolite (K^2O, Na^2O, Li^2O, MnO, Al^2O^3, SiO^2).

Muscovite (K^2O, Al^2O^3, SiO^2).

Phlogopite (K^2O, MgO, Al^2O^3, SiO^2).

Biotite (K^2O, MgO, Al^2O^3, Fe^2O^3, SiO^2).

Margarite (H^2O, CaO, Al^2O^3, SiO^2).

Talc (H^2O, MgO, SiO^2).

Steatite (compact Talc).

As regards structural characters, the minerals of this group fall under the following sections: i. Fibrous (*Asbestus, Krokidolite*); ii. Compact-scaly (*Lepidolite*); iii. Foliated or scaly (*Muscovite, Phlogopite, Biotite, Margarite, Talc proper*); iv. Compact (*Steatite*).

Asbestus and *Krokidolite* are at once distinguished by their occurrence in soft, flexible, fibrous masses, more or less resembling floss-silk. *Asbestus* is chiefly light-green, white or greyish in colour. Thin fibres fuse easily into a colourless or pale-greenish glass. *Krokidolite* or *Crocidolite* is of a deep-blue or lavender-blue colour, and is readily fusible into a black magnetic bead.

Lepidolite (known likewise as *Lithionite* and *Lithia Mica*) occurs essentially in masses of a pink or reddish-grey colour, made up of an aggregation of minute pearly scales, and is readily distinguished by the vivid crimson colour which it imparts to the blowpipe-flame. It melts very easily, with continued bubbling. It occurs also occasionally in foliated or micaceous examples. H commonly about 2·0; sp. gr. 2·8 to 3.

Muscovite and *Phlogopite* are common species of *mica.* They occur essentially in foliated or finely-laminated masses, which admit of separation into the thinnest leaves, and present a metallic-pearly lustre. Also in detached scaly particles, and in hexagonal and rhombic plates and crystals with strongly-pronounced basal cleavage. Thin leaves are flexible and elastic. BB, fine scales become opaque and fuse more or less readily on the edges. *Muscovite* is commonly of a white, brown, black, or greenish colour, and is insoluble in acids. *Phlogopite* is commonly brownish-yellow or golden-brown in colour; and is decomposed in powder by strong sulphuric acid, the silica separating in colourless scales. *Biotite* is a related, ferro-magnesian mica, mostly of a dark-green, black, or dark-brown colour, and like *Phlogopite* is decomposed by sulphuric acid. As a rule (though not exclusively), *Muscovite* forms an essential component of granites, gneissoid rocks and mica slates; whilst *Phlogopite* occurs in connection with crystalline limestones; and *Biotite*, with lavas, trachytes, and basalts.

Margarite or *Pearl Mica* is distinguished from the micas proper, by the comparative brittleness of its component foliæ. It occurs in six-sided tables and lamellar masses of a pearly-white, pale green or pale-reddish colour. H 3·5 to 4; sp. gr. 3. Fusible on the edges with slight intumescence. Contains about 5 per cent. water, but yields little more than traces by ignition in the bulb-tube.

Talc contains from 4 to 5 per cent. of water, but this is only driven off by intense ignition, and thus no water is obtained by ordinary treatment in the bulb-tube—or, at the most, a mere trace only appears upon the glass. *Talc* occurs under two leading conditions: in soft, foliated and scaly examples of a pearly-white, light green or other light colour (= *Talc proper*); and in compact or crypto-scaly masses, white, grey, greenish, &c., or mottled, in colour (= *Steatite*). Both are more or less soapy to the touch, and very sectile. Thin foliæ are flexible but not elastic. Sp. gr. 2·67 to 2·8. H, in *Talc proper*, = 1; in *Steatite* 1·5 to 2·5. BB, both harden considerably, but fuse only on the thinnest edges. See Table XX.

FIFTH GROUP: *Blowpipe characters like those of the Fourth Group, but yielding water (in distinctly visible quantity) on ignition in the bulb-tube.*

SUB-GROUP A: *Fusible, with strong intumescence.*

Stilbite or Desmine CaO, Al^2O^3, SiO^2, H^2O 17 %).

Heulandite (CaO, Al^2O^3, SiO^2, H^2O 15 %).

Chabasite (K^2O, CaO, Al^2O^3, SiO^2, H^2O 21 %).

Apophyllite (KF, CaO, SiO^2, H^2O 16 %).

Thomsonite (Na^2O, CaO, Al^2O, SiO^2, H^2O 13 %).

Scolezite (CaO, Al^2O^3, SiO_2, H^2O, 13 to 14 %).

Laumonite (CaO, Al^2O^3, SiO^2, H^2O 16 %).

Phillipsite (K^2O, CaO, Al^2O^3, H^2O 17 %).

SUB-GROUP B: *Fusible without intumescence.*

Harmotome (K^2O, BaO, Al^2O^3, SiO^2, H^2O 15 %).

Analcime (Na^2O, Al^2O^3, SiO^2, H^2O 8 %).

Natrolite (NaO^2, Al^2O^3, SiO^2, H^2O 9½ %).

SUB-GROUP C : *Fusible only in fine splinters, and then, as a rule, upon the edges merely.*

Chlorite (MgO, FeO, Fe^2O^3, Al^2O^3, SiO^2, H^2O 9 to 12 %).

Ripidolite (A feebly-ferruginous chlorite).

Serpentine (MgO, SiO^2, H^2O 13 %).

Chrysotile (Asbestiform Serpentine).

The representatives of sub-groups A and B belong to the natural group of "Zeolites"—a series of hydrated silicates occurring especially in amygdaloidal cavities of trappean or basaltic rocks. All are very easily fusible (in thin fragments melting in the Bunsen-flame without the aid of the blowpipe), and those of the first sub-group intumesce or foam up on the first application of the flame, whence the name "Zeolite." All are readily decomposed by hydrochloric acid, the silica (in all but *Stilbite, Heulandite, Chabasite* and *Analcime*) separating in a gelatinous state on partial evaporation of the solution. Some of the species scratch glass faintly, and are thus referred to in Table XI. ; but to avoid risk of error in their determination, it has been thought advisable to place them also in the present Table.

Stilbite and *Heulandite* much resemble each other and can only be distinguished properly by their crystallization, which is Rhombic in *Stilbite*, and Clino-Rhombic in *Heulandite.* Both occur commonly in white, brown, or red, foliated and radio-fibrous masses and grouped crystals, with very perfect cleavage in one direction, and strong pearly lustre on the cleavage plane. H 3·5 to 4 ; sp. gr. 2·1 to 2·2. *Chabazite* proper, is easily distinguished by its occurrence in small rhombohedrons, mostly colourless, or white, reddish, &c. H

4 to 5; sp. gr. 2 to 2·2. A variety known as *Phacolite* occurs in very flat twelve-sided pyramids and allied forms, often lenticular from distortion. These species are decomposed without gelatinization by hydrochloric acid.

Apophyllite or *Ichthyopthalmite* occurs in Tetragonal crystals and lamellar masses, colourless or opaque-white, pale-reddish, &c. The crystals are either square prisms with replaced angles, or acute pyramids, mostly with basal plane, the latter shewing a pearly and often iridescent lustre, whilst the other planes are vitreous. The cleavage is parallel with this basal plane, and the cleavage surface is also iridescent-pearly. H. 4·5 to 5: sp. gr. 2·3 to 2·4. !BB, exfoliates and melts with bubbling. *Thomsonite* occurs in rectangular prisms (often acicular), and in fibrous masses, mostly colourless. H 5 to 5·5; sp. gr. 2·3 to 2·4. Fusible, with more or less intumescence. *Scolezite* is much like *Thomsonite* in general characters, although Clino-Rhombic in crystallization, but its salient character (at least in typical examples) is the expansion and pronounced intumescence which it exhibits on ignition. *Laumonite* is also Clino-Rhombic in crystallization, but is commonly in opaque-white efflorescent examples, from loss of water by weathering. H (in unaltered examples) 3 to 4; sp. gr. 2·2 to 2·36. Fusible with intumescence. *Phillipsite* or *Lime-Harmotome* is mostly in small, colourless, cruciform-crystals (but also at times in simple crystals) of the Rhombic System. H 4·5 to 5; sp. gr. 2·2. Fusible with intumescence.

Harmotome, *Analcime*, and *Natrolite*, fuse quietly before the blowpipe — *i. e.*, without preliminary intumescenec. *Harmotome* is readily distinguished by its occurrence in small cruciform-crystals of vitreous lustre; and by the pale-green colour (from presence of BaO) which it communicates to the blowpipe-flame. Its solution in hydrochloric acid, diluted and tested with a drop of sulphuric acid becomes immediately milky from precipitation of $BaSO_4$. *Analcime* may generally be recognized by its occurrence in small trapezohedrons, or in combinations of cube and trapezohedron —the cube shewing three small planes on each angle. Colourless, light-grey, pale-red, &c. H 5·5 (scratches glass more or less distinctly); sp. gr. 2·1 to 2·3. Colours the blowpipe-flame strongly yellow. Decomposed by hydrochloric acid, without gelatinization. *Natrolite* is commonly in radio-fibrous, botryoidal masses, of a brownish-yellow colour, but occurs also in acicular or very small crystals of the Rhombic System, either colourless or lightly tinted. H 5 to 5·5 (scratches glass slightly); sp. gr. 2·17 to 2·27. Tinges the blowpipe-flame strongly yellow. Gelatinizes in hydrochloric acid. The ignition-loss in both *Analcime* and *Natrolite* is under 10 per cent.; in other commonly occurring Zeolites, it varies from 13 or 14, to about 20 per cent.

The minerals of sub-group C, are at once distinguished from those of the preceding sub-groups by their difficult fusibility. As a rule, they exhibit signs of fusion before the blowpipe only on their thinnest edges, or at the point of fine fibres, only. They comprise: the foliated, scaly or crypto-scaly species, *Chlorite* and *Ripidolite*; the compact or slaty *Serpentine*; and the silky-fibrous *Chrysotile*—the latter, properly, an asbestiform variety of *Serpentine*.

Chlorite (= *Pennine*) is normally dark-green in colour, foliated, scaly, or earthy, in structure, and very soft and sectile. Sp. gr. 2·75 to 2·95. Thin scales melt on the edges and surface into a dark, magnetic slag. Some exceptional, chromiferous varieties are dark-red. *Ripidolite* (= *Clinochlore*) is a non-ferruginous or slightly-ferruginous Chlorite. It melts on the edges into a yellowish-grey enamel.

Serpentine occurs normally in compact or fine-granular masses of a green, yellow, red, brown, or greyish colour—two or more colours being often present together in veins and irregular patches. More rarely it occurs in slaty masses (*Antigorite*, &c.), and in fibrous examples, strongly silky in lustre (*Chrysotile*). The latter is usually greenish or yellowish-white in colour, or sometime pale blueish-white. Average sp. gr. of *Serpentine proper*, 2·5 to 2·7.

⁂ *Meershaum* (in white or yellowish, compact, sectile masses; sp. gr. 1·0 to 1·3; yielding 11 or 12 p. c. water on ignition); *Deweylite* or *Gymnite* (in yellowish, waxy-looking masses, yielding 22 p. c. water); *Villarsite*, *Pyrallolite*, &c., also belong to this sub-group. See "Blowpipe Practice," page 221.

TABLE XIX.

[Lustre non-metallic. Hardness insufficient to scratch glass. Infusible, or vitrifying on thinnest edges only. Streak, coloured.]

FIRST GROUP: *Magnetic after strong ignition in a reducing flame.*

Red Iron Ore (Fe^2O^3).

Red Ochre (Earthy Red Iron Ore).

Brown Iron Ore ($Fe^2O^3 + H^2O$).

Yellow Ochre (Earthy Brown Iron Ore).

This group includes only the softer and earthy varieties of *Hematite* and *Limonite*, distinguished respectively by their streak—red in one case, and brownish-yellow in the other. In a reducing flame, these varieties blacken, and become slightly vitrified on their edges, but practically they may be regarded as infusible. After ignition, they readily attract the magnet. *Red Iron Ore* is generally in granular, fibrous, or slaty masses. *Red Ochre* or *Reddle* is merely an earthy variety, sufficiently soft to mark and soil.

Brown Iron Ore occurs in lamellar, granular, and radio-fibrous botryoidal masses of a dark or light-brown colour and ochre-yellow streak. It frequently presents a smooth, glazed surface, and is often iridescent. *Bog Ore* is a sub-earthy variety, commonly containing a certain amount of FeO combined with humic or other organic acid. *Yellow Ochre* is simply the Brown Ore in an earthy condition, soft enough to mark and soil. These varieties give off water in the bulb-tube, and become red when ignited in the free air. Some contain a considerable amount of Mn^2O^3, in which case the powder after ignition assumes a chocolate-red colour, and gives a greenish-blue turquoise-enamel by fusion with carb. soda mixed with a little borax.

Second Group: *Not magnetic after ignition. Streak, pale-brown, or yellow.*

Zinc Blende (ZnS; or [Zn, Cd, Fe] S).

Zincite or *Red Zinc Ore* (ZnO, Mn^2O^3).

Greenockite (CdS).

Zinc Blende and *Zincite*, fused with a mixture of carb. soda and borax in a reducing flame on charcoal, give a sublimate of zinc oxide. This is lemon-yellow whilst hot, and white when cold. Moistened with a drop of cobalt nitrate, and again ignited, it becomes bright-green on cooling.

Zinc Blende is distinguished by its pale-brown streak, and by the formation of an alkaline sulphide by fusion with carb. soda and a little borax in a reducing flame on charcoal. The fused mass, removed from the charcoal, and placed with a drop of water on a silver coin, imparts a dark stain to the surface of the latter. The fusion, however, should be effected by the flame of a candle or oil-lamp, as sulphur is often communicated to test-matters by the flame of gas. *Zinc Blende* also gives off an odour of sulphuretted hydrogen when tested in powder by hydrochloric acid. Many examples of this mineral possess a sub-metallic lustre (see Table VIII.); and some of the dark, ferruginous varieties become slightly vitrified on thin edges before the blowpipe-flame. The more common colours are dark-brown or black, with pale-brown streak, and some of these examples are blood-red by transmitted light. Other examples are dark-green, yellow, &c.; but the streak in light-coloured examples, is almost colourless. *Zinc Blende* occurs commonly in cleavable lamellar masses, in tetrahedrons and other crystals of the Regular System, and occasionally in sub-fibrous examples. H 3·5 to 4; sp. gr. 3·9 to 4·2.

Zincite or *Red Zinc Ore* occurs usually in lamellar and granular masses of a blood-red colour with orange yellow streak. It is commonly associated with *Franklinite*, and is often coated in places with white zinc-carbonate. H 4; sp. gr. 5·5 to 5·7. BB, infusible; with carb. soda mixed with a little borax, gives a greenish-blue turquoise-enamel.

Greenockite or Cadmium Sulphide is comparative rare. It occurs in small pyramidal crystals (acute, hexagonal pyramids with lower half entirely replaced by basal plane) of a yellow or yellowish-brown colour, and yellow streak. H 3 to 3·5; sp. gr. 4·85. BB generally decrepitates, and becomes deep-red whilst hot. Infusible. With carb. soda, gives a red-brown sublimate of cadmium oxide. This is best-seen by rubbing the surface of the charcoal support, previous to the trial, with some powdered chalk or bone-ash.

THIRD GROUP: *Colour green or greenish-blue, paler in the streak.*

Chrysocolla (CuO, SiO^2, H^2O).

Pimelite ($MgO, NiO, Al^2O^3, SiO^2, H^2O$).

Chrysocolla occurs in amorphous botryoidal masses, and in coatings on copper ores. Also, occasionally in pseudomorphs. Green or blue, with very pale streak. H (in solid examples) 2 to 5; sp. gr. 2·0 to 2·6. BB, blackens, but does not fuse. With carb. soda on charcoal gives a globule of metallic copper; and with phosphor-salt, a silica-skeleton. In the bulb-tube yields over 20 p. c. water.

The rare *Dioptase*, a hydrated copper-silicate from Siberia, also belongs to this group, but is hardly likely to come under the student's observation. It occurs in hexagonal prisms, with rhombohedral summit-planes, of a beautiful emerald-green colour. Scratches glass slightly, yields 11·4 p. c. water on ignition, and gelatinizes with hydrochloric acid. Sp. gr. 3·3.

Pimelite occurs in apple-green coatings and earthy masses. BB, blackens, and generally vitrifies on thin edges. With borax in an oxidating flame, forms as amethystine glass which becomes brown on cooling. In the bulb-tube yields about 21 per cent. water. *Nickel-Gymnite* in green or greenish-yellow coatings on certain examples of Chromic Iron Ore, is a closely-related substance.

⁂ See, also, *Chlorite* (Tables XVIII. and XX.), some examples of which present a greenish streak. Commonly in dark-green, foliated, scaly, or compact-scaly masses, sufficiently soft to be scratched by the finger-nail. Infusible, or fusible on thin edges only.

FOURTH GROUP: *Not exhibiting the distinctive characters of preceding groups. Colour black or brownish black.*

Manganese Ochre or Wad (MnO, BaO, MnO^2, H^3O, &c.).

Cobalt Ochre or Asbolan (CuO, MnO^2, CuO, Fe^2O^3, H^2O, &c.).

These Ochres are mixtures of more or less inconstant composition. They occur in black or dark-brown, earthy, stalactitic and other amorphous masses. Both, form a turquoise-enamel by fusion with carb. soda, and the cobalt ochre gives a blue glass, more or less pure, with borax, especially in a reducing flame, when the amethystine colour (imparted to the glass by manganese oxide) becomes destroyed. Both yield water on ignition, and cause the emission of chlorine fumes when warmed with hydrochloric acid.

TABLE XX.

[*Lustre non-metallic. Hardness insufficient to scratch glass distinctly. Infusible, or fusible on thin edges, only. Streak, uncoloured.*]

GROUP 1.—*Yielding water in manifest quantity by ignition in the bulb-tube.*

SUB-GROUP A: *Assuming a blue (or green) colour after ignition with cobalt-solution.*

Alunite (K^2O, Al^2O_3, SO^3, H^2O).

Aluminite or Websterite K^2O, Al^2O^3, SO^3, H^2O).

Wavellite (Al^2O^3, P^2O^5, H_2O).

Gibbsite or Hydrargillite (Al^2O^3, H^2O).

Calamine (ZnO, SiO^3, H^2O).

Allophane (Al^2O^3, SiO^2, H^2O).

Kollyrite (Al^2O^3, SiO^2, H^2O).

Halloysite (Al^2O^3, SiO^2, H^2O).

Kaolin (Al^2O^3, SiO^2, H^2O).

Pholerite or Nacrite (Al^2O^3, SiO^2, H^2O).

Pinite (K^2O, MgO, FeO, Al^2O^3, Fe^2O^3, SiO^2, H^2O).

SUB-GROUP B: *Becoming pale-red or dark-grey (never blue) after ignition with co.-solution.*

Meerschaum (MgO, SiO^2, H^2O).

Deweylite (MgO, SiO^2, H^2O).

Serpentine (MgO, SiO^2, H^2O).

Chrysotile (Fibrous Serpentine).

Antigorite (Slaty Serpentine).

Bastite or Schillerspar (MgO, FeO, Al^2O^3, SiO^2, H^2O).
Chlorite (MgO, Al^2O^3, Fe^2O^3, SiO^2, H^2O).
Brucite (MgO, H^2O).

Alunite, *Aluminite*, *Wavellite*, and *Gibbsite*, are more or less readily soluble (in fine powder) in a hot solution of caustic potash.

Alunite and *Aluminite* are sulphates, and, as such, they form by fusion on charcoal with carb. soda a so-called "hepar" or reddish slag, which imparts when moistened a dark stain to the surface of a silver coin. *Alunite* scratches calcite, and yields on ignition 13 p. c. water. Commonly in granular masses of a white or pale-reddish or yellowish colour, more rarely in small rhombohedral crystals. *Aluminite* yields to the finger-nail, and gives off on ignition about 47 p. c. water. Occurs commonly in white or greyish, porous, earthy masses which adhere to the tongue. Both give off SO^2 by strong ignition ; the evolved water thus reddens litmus paper.

Wavellite is readily recognized by its almost constant occurrence in green, greenish-white, or pale-yellowish, radio-fibrous and botryoidal examples on clay-slate or sandstone. H 3·5 to 4 ; sp. gr. 2·3 to 2·5. BB, tinges the flame pale-green, and separates into fibres which become opaque-white but do not fuse. The solution in nitric acid (or in caustic potash acidified with nitric acid) yields a canary-yellow precipitate on warming with amm. molybdate. In the bulb-tube gives off 25 to 26 p. c. water. Various related species of closely similar character, but differing more or less in their water percentage, are named *Peganite*, *Fischerite*, &c.

Gibbsite or *Hydrargillite* is comparatively rare. Occurs mostly in white or pale greenish-yellow mamillary and stalactitic examples, and in small hexagonal prisms with basal cleavage. H 2·5 to 3; sp. gr. 2·35. BB infusible, but commonly exfoliates. Water percentage, 34·5.

Calamine, *Allophane*, *Kollyrite*, and *Halloysite*, are decomposed with *gelatinization* by hydrochloric acid. The first scratches calcite very strongly, and some examples scratch glass slightly. The others are softer than calcite.

Calamine or *Zinc Silicate* occurs chiefly in aggregations of small, vitreous crystals, and in botryoidal and cavernous masses, either colourless, or brownish, yellowish, &c., and sometimes light-blue from presence of a small amount of copper oxide. But it is chiefly distinguished by yielding a sublimate of ZnO, when fused with a mixture of carb. soda and borax in a good reducing flame on charcoal. The sublimate is lemon-yellow whilst hot, and white when cold; and it becomes light-green when moistened with a drop of cobalt nitrate and again ignited. Another distinctive character (as regards the minerals associated with it in this group) is its property of forming BB with borax a glass which on saturation becomes opaque-white by flaming or when cold. H 5; sp. gr. 3·3 to 3·5. The powder ignited with cobalt solution, becomes partly green and partly blue on cooling. In the bulb-tube yields 7·5 per cent. water.

Allophane occurs in amorphous, botryoidal and similar examples. H 3; sp. gr. about 2. Sometimes mixed with copper silicate and then light-blue or green in colour, otherwise red, brownish, &c. Halloysite and Kollyrite are essentially in white, grey, greenish or other coloured nodular and earthy examples, sufficiently soft, in general, to be scratched by the finger-nail, and somewhat soapy to the touch. The first yields about 24 and the latter about 40 per cent. water. Like other related substances, *Lenzinite*, *Glaegerite*, &c., they are decomposition products of somewhat variable composition.

Kaolin, *Nacrite* or *Pholerite*, and *Pinite*, do not gelatinize in hydrochloric acid, and as a rule are only slightly attacked by that reagent. *Kaolin* (including *Cimolite*, &c. is essentially in very soft, more or less earthy masses, of a white, reddish or other light colour; *Nacrite*, in pearly-white, soft, scaly masses and six-sided tables; and *Pinite* (commonly regarded as a decomposed *Iolite*), in six and twelve-sided prisms, of dull-grey, white, brown, or other colour, and usually opaque. The latter commonly vitrifies on thin edges before the blowpipe-flame. *Fahlunite*, *Gieseckite*, *Esmarkite*, &c., are closely related (see the author's "BLOWPIPE PRACTICE," p. 220 and 226).

⁂ See *Agalmatolite* and *Pyrophyllite* in Group 2, below.

The minerals of Sub-Group B, do not assume a blue colour after ignition with cobalt nitrate. All are essentially magnesian silicates. Colourless examples thus become flesh-red after treatment with the Co-solution, but coloured varieties, as a rule, become dark-grey or dingy-black under this treatment.

Meerschaum, *Deweylite*, and *Serpentine proper*, occur in fine-granular or compact masses of great sectility. Thin splinters, BB, fuse, as a rule, on the extreme edges and harden considerably. *Meerschaum* is white or pale-yellow in colour, and of very low specific gravity (1·2 to 1·3). In hydrochloric acid it gelatinizes. *Deweylite* is also white or yellowish, and somewhat waxy in lustre. H 2 to 3; sp. gr. 1·9 to 2·2. Decomposed, without gelatinization, by hydrochloric acid. *Serpentine* is chiefly green, brown, yellow, red, or greyish—two or more colours often occurring together in veins and patches. H 3 to 4; sp. gr. 2·5 to 2·7. Decomposed by hydrochloric acid, and more readily by sulphuric acid. *Meerschaum* yields about 11 or 12 p. c. water when previously dried at 212°; otherwise, from 12 to over 20 p. c.; *Deweylite* yields about 22 p. c.; and *Serpentine* about 13 per cent.

Chrysotile is a fibrous or asbestiform Serpentine, occurring in soft, silky-looking, parallel-fibrous masses of a yellowish-white or greenish-yellow colour. Fine fibres melt at their extreme point. *Baltimorite* is also a fibrous Serpentine of a blueish colour. *Picrolite*, *Picrosmine*, *Metaxite*, are other varieties of fibrous or bladed Serpentine, usually pale greenish or greenish-white in colour.

Antigorite, *Bastite*, and *Chlorite*, are distinguished from the above by their occurrence in slaty or foliated examples. *Antigorite* is properly a slaty Serpentine, usually deep-green in colour and often translucent. H 2·5 to 3. *Bastite* or *Schiller Spar* occurs in laminated examples of a green or brown colour, with somewhat metallic-pearly lustre, and is probably an altered *Bronzite*. Yields generally about 12 per cent. water. Decomposed by hydrochloric, and more readily by sulphuric acid. H about 3 or 3·5.

Chlorite occurs in foliated and scaly-compact masses and hexagonal tabular crystals, and also in detached scaly particles, mostly of a dark-green colour. Some rare chromiferous examples, however, are dark-red. These form the sub-species *Kœmmererite.* All varieties are sufficiently soft to yield to the finger-nail, and thin pieces are flexible but not elastic. The essentially ferruginous chlorites fuse on thin edges into a black magnetic slag. Other varieties or species (*Ripidolite,* &c.,) vitrify on the edges into a yellowish-grey slag or enamel. In the bulb-tube, all yield from 9 to 12 per cent. water ; and all are decomposed (in powder) by sulphuric acid. H 1 to 1·5 ; average sp. gr. 2·85. Very commonly associated with magnetic iron ore.

Brucite is chiefly distinguished by its occurrence in white or greenish-white, scaly or sub-fibrous, pearly examples, and by the large amount of water (normally 31 per cent.) which it yields on ignition. H 2 ; sp gr. 2·3 to 2·4. Infusible. Becomes flesh-red after ignition with cobalt-nitrate. *Nemalite* is a white or pale-blueish asbestiform variety.

⁂ See, also, *Talc* and *Steatite* in Group 2, below.

SECOND GROUP : *Not yielding water (or yielding traces of moisture only) by ignition in the bulb-tube.*

SUB-GROUP A : *Rapidly and entirely dissolved BB by phosphor-salt.*

Apatite (CaO, P^2O^5, CaF^2, $CaCl^2$).

Scheelite (CaO, WO^3).

SUB-GROUP B : *Slowly attacked BB by phosphor-salt, a silica skeleton remaining in the bead.*

Agalmatolite K^2O, Al^2O^3, SiO^2, H^2O).

Pyrophyllite (Al^2O^3, SiO^2, H^2O).

Talc (MgO, H^2O, SiO^2).
Steatite (MgO, H^2O, SiO^2).
Bronzite (MgO, FeO, SiO^2).
Muscovite (K^2O, Al^2O^3, SiO^2).
Phlogopite ($K^2O, MgO, Al^2O^3, SiO^2$).
Biotite ($K^2O, MgO, FeO, Fe^2O^3, Al^2O^3, SiO^2$).

Apatite, in very fine splinters, is fusible at the extreme point, but may practically be regarded as infusible. Moistened with sulphuric acid, it tinges the flame-point pale-green. *Scheelite* is also practically infusible, although very thin splinters vitrify on the edges in a well-sustained flame. Both species are dissolved readily by fusion with borax, the saturated glass becoming milk-white and opaque on cooling or when flamed. *Apatite* is commonly green, or more rarely reddish-brown, in colour, and is usually in hexagonal prisms (often of large size), sometimes terminated by the planes of a six-sided pyramid. H 5 ; sp. gr. 2·9 to 3·3. The solution in nitric acid gives a canary-yellow precipitate with amm. molybdate, especially on warming. *Scheelite* is at once distinguished by its high specific gravity, 5·9 to 6·2. Also, by giving a blue glass by fusion in a reducing flame with phosphor-salt; and by leaving in nitric acid a yellow or greenish-yellow residuum (WO^3). It occurs commonly in acute, square-based pyramids of a light grey, yellowish, red or brownish colour, but is sometimes colourless or greenish.

As regards SUB-GROUP B, *Agalmatolite* and *Pyrophyllite* become bright-blue on cooling, when moistened with cobalt nitrate and ignited. *Talc* and *Steatite* under this treatment assume on cooling a pale-reddish tint. The other minerals of the sub-group become dark-grey or blackish.

Agalmatolite occurs in fine-granular, almost compact (or crypto-scaly), very sectile, masses; white, yellowish, reddish-white, &c., in colour, and sufficiently soft to be scratched by the finger-nail. Many of the small, Chinese images seen in collections consist of this mineral—hence, its popular name of "Figure Stone;" but some of these images (perhaps the greater number) consist of steatite or serpentine *Pyrophyllite* occurs in very soft, pearly-white, scaly and foliated examples, much resembling Nacrite or Talc, but distinguished by expanding and exfoliating very strikingly under the first action of the blowpipe-flame. It does not fuse, however, beyond exhibiting signs of vitrification on the extreme edges. Both *Agalmatolite* and *Pyrophyllite*, on intense ignition, yield about 5 p. c. water, but when tested in the ordinary manner in the bulb-tube, they give off traces, merely.

Talc proper is readily distinguished by its occurrence in very soft, flexible, scaly and foliated examples, of a pearly-white, apple-green or other colour, distinctly soapy to the touch. *Steatite* is a compact or fine-granular talc, white, grey, greenish, reddish, or mottled in colour, very sectile, and also soapy-feeling. (Hence frequently called "soap-stone," but this name is vaguely applied to compact chlorite, serpentine, &c., as well.) H (in *Talc*) 1; in *Steatite* 1·5 to 2·5; sp. gr. 2·67 to 2·8. BB, both harden considerably, and usually exhibit signs of fusion on very thin edges, but, practically may be regarded as infusible. In the bulb-tube, traces of water are often given off; but the actual (basic?)

water, present to the amount of about 4·5 per cent. in these minerals, is only expelled by intense and long-continued ignition.

Bronzite occurs in schistose or foliated examples of a dark-brown or dark-green colour, with pseudo-metallic bronze-like lustre, and perfect cleavage in one direction. H 4 to 5; sp. gr. 2·9 to 3·5. Not attacked by acids. Infusible, or vitrifying only on thinnest edges in a well-sustained flame. Usually regarded as a foliated variety of *Enstatite*; closely related also to *Anthophyllite*, a substance of very similar aspect, but shewing in typical examples a cleavage angle of 124° 30′, characteristic of *Amphibole*. These minerals are distinguished from micas, by being brittle or non-elastic in thin laminæ, and by their greater hardness.

Muscovite, *Phlogopite*, and *Biotite*—characteristic species of *Mica*—are distinguished by their metallic-pearly lustre and their occurrence in foliated and scaly masses which admit of ready separation into thin, elastic leaves. They occur also in crystals and crystal-plates of hexagonal or rhombic shape, which split in the same manner into fine leaves parallel with the base. BB, thin scales become white and opaque, and fuse more or less readily on the edges; and most examples give off traces of water by ignition in the bulb-tube. *Muscovite* is commonly brown, black, white or greenish in colour, and is insoluble in acids. *Phlogopite* is commonly brownish-yellow or golden-brown in colour, and is decomposed, in powder, by strong sulphuric acid, the silica separating in minute, colourless scales. *Biotite* is a ferro-magnesian mica, (see Text-Books for optical characters), mostly of a dark-green, black, or dark-brown colour, and also decomposable by sulphuric acid. *Muscovite* forms an essential component of granite, ordinary gneiss, and mica slate; *Phlogopite* is found chiefly in connection with the crystalline limestones which are frequently interstratified with gneissoid rocks, and it is very commonly associated with apatite deposits; *Biotite*, on the other hand, occurs principally in lavas, trachytes, and basalts. *Rubellane* (in hexagonal plates and scaly masses of a red or brownish-red colour) is probably an altered *Biotite*.

ADDENDUM.

Anthracite has been accidentally omitted from its proper place in the body of the work. It should be inserted in Group 4 of Table XIX., page 102, or placed *per se* immediately after that Group. Its leading characters are as follows:—Black and lustrous, with greyish-black streak; specific gravity, 1·3 to 1·8; infusible; not attacked by blowpipe fluxes; insoluble in acids and caustic alkalies.

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